DECISION-MAKING IMPLICATIONS OF DIGITAL INFORMATION SYSTEMS FOR THE BATTALION IN COMBAT

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MASTER OF MILITARY ART AND SCIENCE

by

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This study examines the impact of current and developing digital information systems on battalion commanders' ability to make decisions during combat operations. The All Source Analysis System (ASAS) and Force XXI Battle Command Brigade and Below (FBCB2) represent current and developing digital information systems available to battalion commanders for the purpose of the study. As a precursor to the analysis, the study presents and describes naturalistic and normative decision making models. The study analyzes the objective capabilities of these systems to establish the type of information they provide. Then the study analyzes the battalion commander's information requirements for decision making. Information requirements are then re-examined in the context of the environment of combat to establish the degree of certainty information possess in combat.

Having established that combat is a chaotic environment the study concludes that digital information systems do not reduce the amount of uncertainty that battalion commanders perceive when making decisions in combat. Further, the study indicates that battalion commanders use naturalistic decision models to make decisions during combat.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

DECISION-MAKING IMPLICATIONS OF DIGITAL INFORMATION SYSTEMS FOR THE BATTALION IN COMBAT by MAJ Philip L. Swinford, USA, 82 pages.

This study examines the impact of current and developing digital information systems on battalion commanders' ability to make decisions during combat operations. The All Source Analysis System (ASAS) and Force XXI Battle Command Brigade and Below (FBCB2) represent current and developing digital information systems available to battalion commanders for the purpose of the study. As a precursor to the analysis, the study presents and describes naturalistic and normative decision making models. The study analyzes the objective capabilities of these systems to establish the type of information they provide. Then the study analyzes the battalion commander's information requirements for decision making. Information requirements are then re-examined in the context of the environment of combat to establish the degree of certainty information possess in combat.

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LIST OF ABBREVIATIONS

AFATDS	Advanced Field Artillery Tactical Data System
ASAS	All Source Analysis System
AWE	Advanced Warfighting Experiment
C2	Command and control
CCIR	Commander's critical information requirements
COA	Course of action
CTC	Combat Training Center
DCE	Digital communications equipment
DIS	Digital information system(s)
DSM	Decision support matrix
DSSU	Digital Soldier System Unit
DST	Decision support template
EEFI	Essential elements of friendly information
EPLRS	Enhanced Position Location Reporting System
EXFOR	Experimental Force
FBCB2	Force Twenty-one Battle Command--Brigade and Below
FFIR	Friendly force information requirements
FM	Field Manual
GBCS	Ground Based Common Sensor
GPS	Global Positioning System

GRCS	Guardrail Common Sensor
JSTARS-CGS	Joint Surveillance and Target Attack Radar System-Common Ground Station
IPB	Intelligence Preparation of the Battlefield
IR	Information requirement
IRC2	Information requirements for command and control
IVIS	Intervehiclar Information System
MCS	Maneuver Control System
MDMP	Military Decision Making Process
MIES	Modernized Imagery Exploitation System
NDP	Naval Doctrine Publication
NTC	National Training Center
ODH IV	OPERATION DESERT HAMMER IV
OODA	Observe, orient, decide, and act
OPFOR	Opposing force
PIR	Priority information requirement
POSNAV	Position navigation
RPD	Recognition-Primed Decision making
R&S	Reconnaissance and surveillance
SINCGARS	Single Channel Ground and Airborne Radio System
ST	Special Text or Student Text
TF	Task force
TLP	Troop Leading Procedures
TRADOC	Training and Doctrine Command
USAHEL	U.S. Army Human Engineering Laboratory
UAV	Unmanned aerial vehicle

CHAPTER 1

INTRODUCTION

Decision-making has always been an essential part of the commander's job. History shows numerous examples of commanders who failed to make quality, timely decisions resulting in tactical, operational, and even strategic reverses. The staff and their processes were developed to support the commander in his decision-making through the collection and analysis of information. The idea was to gather and analyze the right amount of information to determine the best solution to this problem. This had to be accomplished quickly enough for the commander to issue instructions to his subordinates and still allow them time to analyze their own roles. Under a time constraint the staff had less time to develop their input and commanders had to make decisions without the full benefit of staff input.

This study focused on determining how digital information systems (hereafter referred to as DIS) impact the decision-making component of battle command for small unit commanders during execution of an operation. Shortly after the U.S. Army published its primary doctrine, FM 100-5 *Operations*, in 1993 the Chief of Staff of the U.S. Army, General Gordon R. Sullivan, directed that the Army begin preparing for the environment of the Twenty-first Century. General Sullivan called this future army, Force XXI.[1] The concept of Force XXI was a response to the rapid pace of evolution in information technology and its potential impact on future conflict. The Army was attempting to leverage these technologies to gain a quick lead in information systems over possible adversaries.[2]

Some uses of DIS include direct action against enemy information systems (command and control warfare, electronic warfare, etc.) and psychological operations. Other uses include the

collection, analysis and dissemination of information to friendly units. This type of DIS use supports decision-making. The theory was that the use of emerging digital technologies permitted the development of information systems that increased the amount of information available to commanders at all levels simultaneously. The increase of information allowed a near perfect shared awareness of friendly and enemy units and actions. Improving commanders' shared awareness was expected to enhance commanders' decision-making and allow units to operate at a tempo that enemies could not sustain.[3] Shared awareness or visualization facilitated decision-making at all levels of command because it reduced the uncertainty associated with conflict.[4]

Do DIS reduce the uncertainties of war? If so, how much and what kind of information do commanders need to reduce uncertainties to facilitate decisions? Do the current DIS, All Source Analysis System (ASAS) and Force XXI Battle Command-Brigade and Below-Appliqué (FBCB2 or appliqué), provide the right kind and amount of information to facilitate decisions? Do commanders make decisions during operations analytically or intuitively? Do decision makers require analyzed information? How does the volume of information that DIS produce affect the decisions made by commanders? Understanding how humans (commanders) make decisions is essential to studying the impact that DIS will have on decision-making. Therefore, this research explored the question: Do current and developing DIS enhance battalion commanders' decision-making during execution?

The U.S. Army is committed to redesigning itself for the Twenty-first Century, becoming *The Army of the Twenty-first Century--Force XXI*. Battle Laboratories throughout the U.S. Army Training and Doctrine Command seek ways to exploit the explosion of digital information technologies to enhance warfighting. The Army has established an Experimental Force (EXFOR) to test the concepts and equipment of Force XXI in Advanced Warfighting Experiments (AWE). Throughout this vast process of change the human mind remains a relative constant.

Understanding the mind of its leaders and soldiers is essential if the Army is truly to exploit the available DIS. Soldier-machine interface is not just limited to the ergonomics of the

keyboard. DIS may overburden soldiers and commanders by providing too much information or by requiring too many decisions. By examining how commanders make decisions and how information technology impacts on those decisions this study attempted to scratch the surface of the implications of Force XXI.

Assumptions

In order to determine the affect of DIS a number of assumptions were necessary: (1) commanders will make the best decision they believe will accomplish the mission, (2) commanders make decisions during combat execution under crisis conditions, and (3) current research has developed an adequate model for crisis decision-making. The first assumption indicates that commanders will choose the optimal course of action from a range of alternatives given their understanding of their unit's capabilities, tactics and techniques, the current situation, and their experiences. In any given tactical situation commanders will attempt to use Army doctrine as they perceive it in the formulation of a solution. This assumption is necessary to provide a framework for commander's decisions. The second assumption is required to establish the environment of the commanders' decision-making during combat as opposed to decision-making during planning. The nature of crisis decision-making may affect how commanders make decisions and differentiate those decisions made during combat from those made during planning. The last assumption is required to test the thesis. A valid model of crisis decision-making establishes the process and information requirements for combat decision-making.

Definitions

The advent of digital information technologies resulted in an imposing array of new terms. Terms such as byte, hard drive, and software are common today in everyday language. Defining eleven key terms pertinent to this study is essential to facilitating the reader's understanding:

Battle Command. A concept that includes both command and control. It requires that commanders visualize the battlefield, make and implement decisions, and lead soldiers.[5]

Command. The legal authority exercised by commanders to direct soldiers and units.[6]

Control. Control is monitoring the status of subordinate compliance with command directives and correcting deviating behaviors as required.[7]

Decision-making. "A psychological process of choice among different alternatives as perceived and formulated by the decision maker for the sake of action while he tries to optimize goals and avoid risks using a minimum amount of resources."[8]

Crisis. A crisis is a change in the external or internal environment of an organization, threat to the existence or mission success of a unit, or a situation in which there is a finite amount of time to react.[9]

Information Technology. Technology focused on the collection, communication, and use of information.[10] This research deals specifically with digitized microprocessing technologies as applied to the collection, communication, and use (analysis) of tactical information within military units.

Information Warfare. "The ability to manipulate, isolate, or negate portions of the electromagnetic spectrum" and "disruption of an opponent's ability to use these systems."[11]

U.S. Army Doctrine. "The authoritative guide to how Army forces fight wars and conduct operations other than war";[12] specifically, the 1993 version of FM 100-5, *Operations*, and supporting publications.

Information System. "The entire infrastructure, organization, personnel, and components that collect, process, store, transmit, display, disseminate, and act on information."[13] This study deals specifically with military digital information systems (DIS) organic to U.S. Army battalions (see Delimitations for further specification).

Normative Decision Model. A decision aid which uses Decision Analysis and Multi-Attribute Utility Analysis, Bayesian statistics, and/or other analytical tools to improve decision-

making. Normative decision-making requires comparing several courses of action, given a set of criteria, to determine the optimal course of action.[14] The U.S. Army's Military Decision-making Process (MDMP) is an example of a normative decision process.

Naturalistic Decision Model. An alternative decision model that focuses on recognition of changes in the situation to initiate decision-making as opposed to the analytical approach of the normative model. In the naturalistic model the decision maker does not seek the optimal course of action, but one that is workable.[15]

Limitations

This study focused on the impact of DIS during the execution of combat operations. Commanders of units brigade sized and larger rarely participate in direct contact during operations. Likewise, commanders of certain combat, combat support and combat service support units rarely participate in direct combat. Therefore, this study was limited to U.S. Army infantry and armor battalions.

DIS are relatively new to the U.S. Army. The number of officers who have served in units so equipped is very small. Moreover, no unit has yet exercised with a complete set of DIS available at the battalion level. Officers who have served in or commanded such units represent an extremely small sample size. Considering the short development of DIS (1993 to present) there are probably not more than thirty field grade officers who have relevant experience with DIS equipped units. Therefore, a survey of officers was impractical and would have yielded insufficient data.

Delimitation

The analysis concentrated on the period 1993 to the present. DIS testing and use prior to 1993 was either experimental or linked to existing analog information systems. The research analyzed only those operation orders and unit performance records archived at Ft. Leavenworth or in the author's possession. Because of the indistinct nature of DIS development the study focused

on two DIS currently in use or under development in the U.S. Army. The chosen systems represent the most significant features of DIS--the ability to receive and share information without regard to the size of the unit. Those systems were the All Source Analysis System (ASAS) and Force XXI Battle Command - Brigade and Below-Appliqué (FBCB2-Appliqué, appliqué, or FBCB2). ASAS communicates with national, joint, and army intelligence collectors. It provides timely access to intelligence products developed by these sources, and can process, analyze, and report large volumes of intelligence. Intelligence sources include Ground Based Common Sensor (GBCS), Guardrail Common Sensor (GRCS), Modernized Imagery Exploitation System (MIES - imagery normally satellite produced), Joint Surveillance and Target Attack Radar System Common Ground Station (JSTARS-CGS) as well as other systems.[16] Essentially, ASAS is an information data base that receives, stores, manipulates, and presents information collected by sensors from the national or strategic level to tactical level. This information can be in any format: imagery, signals intelligence, human intelligence, electronic intelligence and others. FBCB2 is a family of computers linked to the single-channel ground and airborne radio system/enhanced position location reporting system (SINCGARS/EPLRS). It provides information processing and display capabilities in a variety of combat systems.[17] Normally each special platoon leader, company commander, and battalion commander will have a FBCB2 available. The FBCB2 communicates digitally over the SINCGARS/EPLRS providing position location of the system to the user and to other users equipped with this system. FBCB2 also communicates with the ASAS, the Maneuver Control System (MCS), the Advanced Field Artillery Tactical Data System (AFATDS) and the Dismounted Soldier System Unit (DSSU).[18] In short, FBCB2 is a tactical internet that allows users to access all available information within the system.

This chapter established the background of this study. It focuses the study on battalion commander's decisions made during the execution of combat operations as opposed to decisions during planning. In theory this should be where DIS has its most significant consequence in

changing the way the Army operates. In the next chapter the study examines literature relevant to the study.

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[1]Department of the Army, United States Army Training and Doctrine Command Pamphlet 525-5, *A Concept for the Evolution of Full-Dimensional Operations for the Strategic Army of the Early Twenty-First Century* (Fort Monroe, VA: Headquarters, United States Training and Doctrine Command, 1994), i-iii.

[2]Brian Nichiporuk and Carl Builder, *Information Technologies and the Future of Land Warfare* (Santa Monica, CA: RAND, 1995), 1-5.

[3]TRADOC Pam 525-5, 1-5.

[4]Ibid., 3-4 and 3-5.

[5]Department of the Army, Field Manual 100-5, *Operations* (Washington D.C.: Headquarters, Department of the Army, 1993), 2-14, 2-15.

[6]Ibid., 2-14.

[7]Ibid., 2-15.

[8]Gabriella T. Heichal, "Decision-making During Crisis: The Korean War and Yom Kippur War" (Washington, D.C.: The George Washington University and University Microfilims International, 1984), 8-9.

[9]M. Brecher, "Towards a Theory of International Crisis Behavior, A Preliminary Report," ISQ, 21, no. 3, March 1977, 43-44 quoted in Gabriella T. Heichal, "Decision-making During Crisis: The Korean War and Yom Kippur War" (Washington, DC: The George Washington University and University Microfilims International, 1984), 15.

[10]TRADOC Pam 525-5, 2-2.

[11]Ibid., 2-7.

[12]FM 100-5, v.

[13]Department of the Army, Field Manual 100-6, *Information Operations* (Washington, DC: Headquarters, Department of the Army, 1996), Glossary-8.

[14]Gary A. Klein, Marvin L. Thordsen, and Roberta Calderwood, "Descriptive Models of Military Decision-making," ARI Research Note 90-93, Prepared by Klein Associates for the U.S. Army Research Institute for the Behavioral and Social Sciences (Fairburn, OH: Klein Associates Inc., 1990), 1.

[15]Ibid., 2-4.

[16]Department of the Army, Student Text 100-3, *Battle Book* (Fort Leavenworth, KS: U.S. Army Command and General Staff College, Center for Army Tactics, 1996), 3-11 through 3-24.

[17]FM 100-6, 5-3.

[18]Department of the Army, Special Text 7-20, *The Digitized Infantry Battalion* (Washington, DC: Headquarters, Department of the Army, 1996), 3-2.

CHAPTER 2

LITERATURE REVIEW

This chapter organizes the literature into three categories: background, doctrine, and decision-making. The background discusses general literature on information technology as applied to warfare. Significantly, this illustrates that while there is considerable debate about DIS technology as it is applied to warfare there is little investigation of its impact on the commander's decision-making. This section also details reports on developing DIS from past exercises conducted by the U.S. Army. The doctrine section examines the current and emerging doctrine for decision-making and the use of information technology. The final category examines decision-making theory and behaviors used in this study.

Background

A number of documents are available on the subject of information warfare. Most address how DIS are to facilitate the flow of combat information in a time sensitive fashion. Significantly, the U.S. Navy's doctrinal publications do address certain aspects of the impact of DIS on decision-making. The U.S. Army has sponsored limited experimentation in the digital enhancement of combat unit information management. Reports from these experiments, while inconclusive, are particularly insightful. All these documents are applicable to this research; however, none deals specifically with the impact of DIS on battalion commander decision-making during execution.

A key work on how DIS enhances of combat information flow is *Information Technologies and the Future of Land Warfare*, by Brian Nichiporuk and Carl Builder. It

describes a vision for change based on information technology. It discusses the thought that Army units may pass information with one another based purely on need and the task at hand. This is generally at odds with the current practice of passing information through the chain of command.[1] The Army has not been blind to the idea of sharing information between subordinate units based on the mission. Many units and commanders stress the need for "cross-talking" between subordinate commanders to exchange critical information. The Army is vague on how this effects decision-making, linking subordinate decisions to the "commander's intent." Nichiporuk deals mostly with information flow hierarchy and does not address how decisions will be made within this hierarchy.

Lieutenant Colonel James Sikes discusses the impact of this information sharing in *Battle Command and Beyond: Leading at the Speed of Change in the 21st Century*. He indicates that the force that best accomplishes information sharing will be able to seize the initiative and act quicker when given an opportunity, provided they have skilled leaders. He postulates that the demands placed on commanders in these fluid situations will require commanders to analyze, decide, and execute nearly simultaneously.[2] Despite their optimistic predictions none of these works deal specifically with the impact of DIS on decision-making.

In *Battalion Level Tactical Decision Making: Can Automation Make A Difference?* Major Gregory Bozek establishes criteria for a digital command and control system by examining five decision-making tasks. These tasks are: acquire information, (2) maintain status, (3) assess information, (4) determine actions, and (5) direct and lead subordinate forces. The criteria he develops focuses almost exclusively on information management and communication. The criteria are:

> 1. Allow the commander to receive and transmit both qualitative and quantitative information.
> 2. Provide the commander the capability to move on the battlefield and operate from his combat vehicle.
> 3. Minimize the physical workload of the commander in maintaining maps and status charts.
> 4. Minimize the unnecessary cognitive workload on the commander. . . , through the use of command designated filters, and presenting the information in a useable format.

5. Provide the commander two-way communications.
6. Provide accurate, near real-time information.
7. Allow access to critical information continuously and to other information as required.
8. Support the commander's ability to articulate orders and operations graphics.
9. Provide the commander the flexibility to deal with unforeseen circumstances.[3]

These criteria indicate that a DIS simply acts as an extension of the staff. It provides a means for the staff to communicate that information that it has to the commander. Thus, the DIS allows the commander to decide more quickly because he has the information readily at hand, and that may be all it can do. This approach assumes that a commander's decision-making under combat conditions is a matter of assimilating facts and making a decision using analysis. Bozek's concern for "qualitative information" flow to the commander is indicative of his discomfort with this type of decision-making. He asserts that the command and control system must allow commander's to talk to subordinates to motivate, encourage, and lead them.[4] Bozek assumes that commanders use normative or analytical decision-making at all times. Bozek's paper is enlightening, but fails to illustrate the effect of DIS on decision-making during execution.

The U.S. Navy addresses the relationship between the methods naval commanders use to decide and the application of DIS in NDP 6, *Naval Command and Control*. Given the Navy's years of experience with DIS this document provides a valuable perception relevant to this study. The Navy bases its decision and execution cycle on Colonel John Boyd's "OODA Loop" (see figure 1) and sees it as a continuous, cyclical process. The naval commander initiates (or continues) the process by observing his environment using any variety of sensors available to him. He and his staff then process the raw observations to develop combat information that builds a common tactical picture. The common tactical picture is the analogous representation of the observations as displayed by available media. This analogy allows the commander to orient himself by creating a mental image of his environment. In the process of orienting himself the commander applies judgment to the processed information in order to gain understanding. The

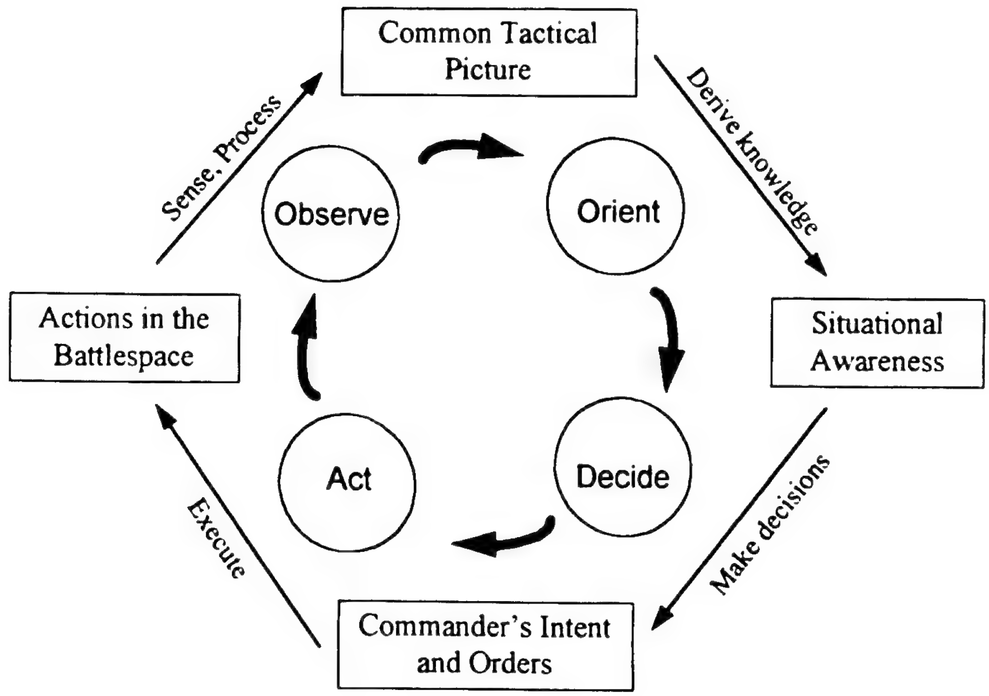

Figure 1. The U.S. Navy Decision and Execution Cycle. source: NDP 6, *Naval Command and Control* (Washington, DC: Office of the Chief of Naval Operations, 1995), 18, fig. 2-1.

commander's understanding of the environment is his situational awareness. He then decides on a course of action based upon his situational awareness. The selected course of action is further refined and then communicated through the commander's intent and orders. These orders initiate or modify the actions of the naval unit. The subsequent interaction between friendly and enemy naval forces then begins the cycle anew.[5] Hence, The Navy's decision and execution cycle indicates that the commander can only decide after he has achieved an understanding of his environment.

Naval Command and Control goes on to assert that DIS only supports decision-making by providing raw data and, to a lesser extent, by formatting and processing that data into combat information. DIS has a very limited role in allowing the commander to build his situational

awareness. Further, the Navy acknowledges that at some point in the decision and execution cycle gathering additional information only provides greater detail and does not enhance situational awareness. In fact NDP 6 states that:

> Beyond this point additional information may have the opposite effect--it may only serve to cloud the situation, impede understanding, and cause the commander to take more time to reach the same decision he could have reached with less information.[6]

The limitation of DIS in the ability to enhance decision-making implied by this statement are clear. DIS aids decision-making only by providing information, and too much of that can detract from the decision maker's ability to decide.

The Army wanted to find out how much information was too much. In 1982 the U.S. Army Human Engineering Laboratory (USAHEL) conducted the Information Requirements for Command and Control (IRC2) study to explore the effects of electronically displaying sitiuational awareness information on the effectiveness of tank platoons in combat. Comparing the decision-making of platoon leaders to that of battalion commanders may seem a little like comparing apples to oranges. However, the decisions made by platoon leaders are every bit as difficult as those made by battalion commanders. Poor choices in either case could lead to catastrophic results for the individual, his unit, and his mission. Neither will have sufficient time to consult with others or to examine the details at length. The primary difference between the battalion commander's decision and the platoon leader's is a matter of scale. The platoon leader may have less time and more to lose, personally, from inadequate decisions. Thus, the IRC2 study is relevant and provides interesting insight into the use of DIS in enhancing situational awareness and supporting decision-making for battalion commanders.

The study tested six platoons (five tank) using the German Automatic Tank Combat Simulation System under three different conditions in movement to contact and defensive scenarios. Condition one was the control state with no situational awareness enhancement. In condition two the "blue" platoon leader had friendly positions depicted on his work station. In

condition three the "blue" platoon leader had both the friendly and enemy positions depicted on his work station. "Red" platoons were always in condition one. The simulation was similar to many current commercial personal computer games in that its graphics represented a view of the battlefield from above. The movement to contact pitted one platoon against another, while the defense had one "blue" platoon against two "red" platoons. The study's results stated that platoons with enhanced situational awareness were more effective because they "won" more engagements (see table 1). The results of the study seemed to indicate that there was value in enhanced situational awareness but were inconclusive.

Table 1. IRC2 Condition Level to "Blue wins"

"Blue" Condition level	Defense "Blue wins"	Movement to Contact "Blue wins"
1	4 of 12	3 of 12
2	10 of 12	2 of 12
3	8 of 12	7 of 12

Source: J.R. Walker and J. Reimer, "Information Requirements for Command and Control: Phase 1A," Technical Note 6-84 (Aberdeen Proving Ground, MD: USAHEL, 1984), 26 and 32, tables 8 and 19.

This analysis is somewhat simplistic. The study observed that platoon leaders were less involved with fighting their own combat vehicle and the platoon when equipped with the enhanced situational awareness tools. In the defense, platoon leaders fired an average of twenty-two percent of the engagements when in condition one, but only five percent when in condition three. In the offense these figures were twenty-two percent and eight percent respectively. This result could have been caused by the fact that the platoon leaders' vehicles were the only ones equipped with the enhanced situational awareness system and they became overly involved with passing information rather than leading their platoons.

Table 2. IRC2 Individual Platoon Results

Mission	"Blue" platoon	Condition level	Number of "wins"	"Red" platoon(s)	Condition level	Number of "wins"
Defense	3	3	3 of 4	1 and 2	1	1 of 4
Defense	3	1	3 of 4	1 and 2	1	1 of 4
Defense	2	3	1 of 4	1 and 3	1	3 of 4
Defense	2	1	1 of 4	1 and 3	1	3 of 4
Defense	2	2	3 of 4	1 and 3	1	1 of 4
MTC	4	1	0 of 4	6	1	4 of 4
MTC	4	2	0 of 4	6	1	4 of 4
MTC	4	3	0 of 4	6	1	4 of 4
MTC	5	2	0 of 4	4	1	4 of 4
MTC	5	3	3 of 4	4	1	1 of 4
MTC	5	1	1 of 4	4	1	3 of 4
MTC	6	3	4 of 4	5	1	0 of 4
MTC	6	1	2 of 4	5	1	2 of 4
MTC	6	2	2 of 4	5	1	2 of 4

Source: J.R. Walker and J. Reimer, "Information Requirements for Command and Control: Phase 1A," Technical Note 6-84 (Aberdeen Proving Ground, MD: USAHEL, 1984), 26 and 32, tables 8 and 19.

An examination of the platoons' individual results shows a striking contrast to the overall evaluation that the enhanced platoons were more effective (see table 2). Platoon four "won" eight engagements of the twenty-four it was involved in. In all eight of these engagements the platoon was in condition one. Interestingly, platoon four's leader was a recently reclassified Sergeant First Class who may have had only twenty-four months experience as a tank crewman, and possibly less as a platoon leader. Platoon six "won" twenty of twenty-four engagements, fourteen in condition one. Platoon three "won" twenty-one of thirty-six engagements, fourteen of these in condition one. Clearly the platoons were not equal. Something in the training and experience of platoons three and six allowed them to be successful regardless of the condition level they were in. The study recognized that the tactical capabilities of the platoons played a role in the results and recommended continued experimentation under more controlled conditions[7].

More recently, the U.S. Army has conducted a number of AWEs to test the DIS concepts. Operation DESERT HAMMER IV (ODH IV) tested a partially digitized heavy brigade during National Training Center (NTC) rotation 94-07. The brigade consisted of one armor Task Force (TF) (minus) and a balanced mechanized infantry TF. The armor TF was equipped with ASAS (at the TF level) and early versions of FBCB2 down to company and platoon level. The armor TF (or digital TF as it was known) was the focus of ODH IV. The mechanized infantry TF had EPLRS and Situational Awareness Hosts (similar to FBCB2) down to company/team level. The "Operation Desert Hammer IV - Final Report" provides insight into some of the findings of the AWE. Members of the unit felt that they achieved a shorter decision cycle time. Their comments generally centered on an improved friendly situation and position location awareness. The report indicates that there was no significant difference in decision times between the digital TF and normally equipped units. Further, the report discusses the inability of the TF S2 (Intelligence Section) to process the volumes of available information to create a "picture" of the enemy situation for the commander. Finally, the digital TF appeared to be able to increase the level of participation of combat systems. However, the TF was unable to synchronize these systems any better than normally equipped units.[8] Synchronization of combat systems, or lack thereof, is a significant indicator of the quality of the commander's decisions. A number of these shortcomings were, no doubt, due to the poor technical reliability of the equipment and the relative inexperience of the operators. Additionally, the armor TF was an ad hoc unit and was to a large extent less prepared for the rotation than normally equipped units. More recent exercises continue to remark on the inability of the S2 section to input the available enemy information, much less analyze it.

In summary, this section examined recent documents that discuss certain aspects of DIS enhancement to information management and decision-making by combat commanders. These documents describe some of the challenges and benefits to combat decision-making for battalion commanders using DIS. The Army attempted to define some of these benefits and explore the possibility of equipping tactical units with DIS. Initial Army experimentation suffered from

uncontrolled variables, such as the state of unit and operator training. As a result, the experiments have not conclusively shown that DIS will enhance decision-making during execution.

Doctrine

An examination of U.S. Army publications is essential to understanding how the Army envisions commanders using DIS. This vision is part of the Army's ever evolving doctrine. The chief source of this vision is the 1993, FM 100-5, *Operations*. This document attempts to envision the conflicts of the future and the impact of technology on operations and commanders.[9] A second key source is the United States Army Training and Doctrine Command Pamphlet 525-5, *A Concept for the Evolution of Full-Dimensional Operations for the Strategic Army of the Early Twenty-First Century* (TRADOC Pam 525-5). This document provides Army planners, doctrine writers, trainers, and combat developers with direction for the changing Army. It addresses information technology implications for future commanders and leader developers.[10] It explains the Army's vision for DIS enhancement to tactical units. Lastly, and most important to this research is FM 101-5, *Staff Organizations and Operations*. This publication describes the U.S. Army's primary decision-making model. Any effort to understand how Army commanders make decisions must consider this manual. Together these publications provide this study with the Army's overall vision for command in battle; direction and purpose for experimentation with, and use of DIS; and a description of decision-making.

The core of the U.S. Army's operational doctrine is contained in FM 100-5, *Operations*. In *Operations* decision-making is described as a part of Battle Command. Battle Command essentially consists of two components, command and control. Command provides direction to subordinate units by assigning missions, motivating soldiers, and allocating resources. The application of command is often driven by intangibles such as the commander's intuition. Control is that part of Battle Command which deals with identifying, correcting, and preventing deviations

from the commander's concept or some other standard.[11] As such, control directs the burden for decision-making upward towards the commander.

Operations subdivides command into two subcomponents, decision-making and leadership. It implies that visualizing the battlefield is an inherent requirement for decision-making. The vision is the commander's mental image of the actions and missions of his and the enemy's units on the terrain over time. Building this image requires that the commander gather, process, and understand information. The commander's vision allows him to determine if, when, and what to decide. Further, *Operations* states that the commander must anticipate the outcomes of his decision. The leadership subcomponent consists of taking responsibility for decisions and motivating subordinates. Part of motivating subordinates includes providing a certain degree of freedom of action to them so they can accomplish assigned missions as they see fit.[12] This effectively pushes the requirement for decision-making downward to subordinate commanders. In effect, the subordinate freedom of action given by command is balanced by the limitations of control.

To guide commanders in balancing command and control, *Operations* offers what is commonly known as "mission tactics" or "mission orders." Mission tactics are a derivative of *Auftragtactics* as developed and practiced by the Germans. It was formally adopted by the U.S. Army in the 1982 version of FM 100-5.[13] The application of mission tactics requires the subordinate commander to exercise his freedom of decision and action to accomplish his unique contribution, or purpose, within the confines of the higher, and higher, higher commanders' intents and concepts. Emphasis on the purpose of the operation leads the subordinate commander to focus on the higher commanders' anticipated outcome, or endstate.[14] The result is that all subordinate commanders make decisions that tend to be similar to the one that the higher commander would make if he had the information available to the subordinate commander. By employing mission tactics the commander expands his ability to understand and react to his environment. This is particularly important when that environment has become so chaotic that it

invalidates his original decisions and intended actions. Hence, mission tactics allow the commander to exponentially increase his ability to assimilate information, make, and enact decisions on a battlefield of ever increasing complexity.

TRADOC Pam 525-5 asserts that DIS may offer a new way for commanders to increase their ability to command and control operations. It states that the advances in information technology will cause an evolutionary and a revolutionary change in military operations. The first is the increase in speed, volume, and accuracy that DIS makes available to commanders. The second, the revolutionary change, is a requisite reassessment of how armies exercise command and control. Units equipped with DIS will communicate, based on need and function, in the traditional hierarchical fashion and in a novel non-hierarchical fashion. The combination of centralized and decentralized information management will allow commanders and their subordinates to make and implement decisions much faster than the enemy.[15] The hypothesis of Force XXI operations is that the increased speed, volume, and accuracy of information made available to commanders by DIS results in faster decisions.

Exactly how commanders make decisions is not made clear in TRADOC Pam 525-5. Force XXI's DIS are expected to supply a "common, relevant picture" to all subordinate commanders. This digitized display is the result of the integration of information about friendly and enemy locations and actions. The common picture reduces uncertainty and improves subordinate understanding of commander's intent. These subordinates, now fully understanding the commander's intent and their own location on the battlefield, will be more capable of independent action. TRADOC Pam 525-5 implies that because higher commanders will be fully capable of monitoring the actions of subordinates they will be less likely to interfere in subordinate decision-making. Force XXI units will also utilize automated decision-making systems for recurring functions. Finally, the commanders of Force XXI units are expected to acquire intuitive decision-making skills from study and experience and apply their intuition to battlefield decision-making. TRADOC Pam 525-5 recognizes that commanders cannot wait for

complete information and expects them to act in uncertain situations.[16] An examination of the Army's decision-making process provides insight into how much uncertainty is acceptable, and how commanders will use available information to make their decisions.

The Army's primary reference for decision-making is FM 101-5, *Staff Organizations and Operations*. This manual is currently under going revision and is available as a revised final draft dated August 1996. FM 101-5 (Final Draft) discusses three key elements relevant to this study; the Military Decision Making Process (MDMP), decision-making in time constrained environments, and the development of the commander's critical information requirements (CCIR).

The MDMP (figure 2) is an analytical decision-making model that attempts to determine the best possible course of action. The commander is responsible for developing the overall concept for the operation and for deciding which course of action is to be used. The staff is responsible, as the commander sees fit, for analyzing the friendly and enemy situation and courses of action and the conditions of the terrain and weather. The staff input to the MDMP is critical to analyzing the information available and to determining the optimum course of action. FM 101-5 (Final Draft) describes MDMP as "time consuming".[17]

The first step of the MDMP, Receive the Mission, begins when the unit receives an order from its higher headquarters or when the commander deduces a change of mission. The second case assumes that the commander has examined the situation and determined that he can or must accomplish his higher commander's intent with a new or modified plan from that which he is currently executing. This deduction requires the commander to recognize the changing situation and make the decision to adapt to it. Upon receipt of the new mission, whether from higher or deduced by the commander, the staff begins gathering information that is relevant to the problem. A significant portion of this information deals with the status of the friendly unit. Information on the enemy situation and intentions, the terrain, and the projected weather and light data make up the balance of the required information. The commander and staff allocate available time for planning and preparation activities. Finally the commander issues his initial guidance which

includes his decision on how much time will be allocated to the completion of the MDMP, how to abbreviate it if required, and guidance on initial reconnaissance.[18] The initial reconnaissance plan, communicated to the subordinate units in a warning order, includes the commander's current or initial CCIR.[19] These information requirements are focused on information that the commander needs to develop courses of action and to make decisions.

The second step, Mission Analysis, actually begins during step one. The staff analyzes the information gathered in step one and contained in the higher order. This analysis follows an 18 step (see figure 2) process and should focus on the effects the analyzed information might have on course of action (COA) development. The staff then briefs the commander on the essence of their analysis. The commander conducts a parallel analysis of the mission and prepares his guidance for COA development, including additional reconnaissance guidance. During the mission analysis the commander and his staff identify facts, develop assumptions, and refine CCIR. FM 101-5 (Final Draft) defines facts and assumptions as

> statements of known data concerning the situation, including enemy and friendly dispositions, available troops, unit strengths, and material readiness. Assumptions are suppositions about current or future situation, which are assumed to be true in the absence of facts.[20]

The final step of mission analysis is to review the facts and assumptions. This is a continuous process that requires the commander to test facts and assumptions, reassess their significance, and modify the plan whenever appropriate.[21]

The third through sixth steps of the MDMP are closely linked. In step three, COA Development, the staff uses the information analyzed in the first steps and the commander's guidance to develop a number of draft plans to address the operation. The goal of this step is to develop enough distinct COAs that reasonably can accomplish the mission to allow the commander and staff to analyze and compare them. The staff analyzes each COA against possible enemy actions given the enemy capabilities. This analysis allows the staff to determine

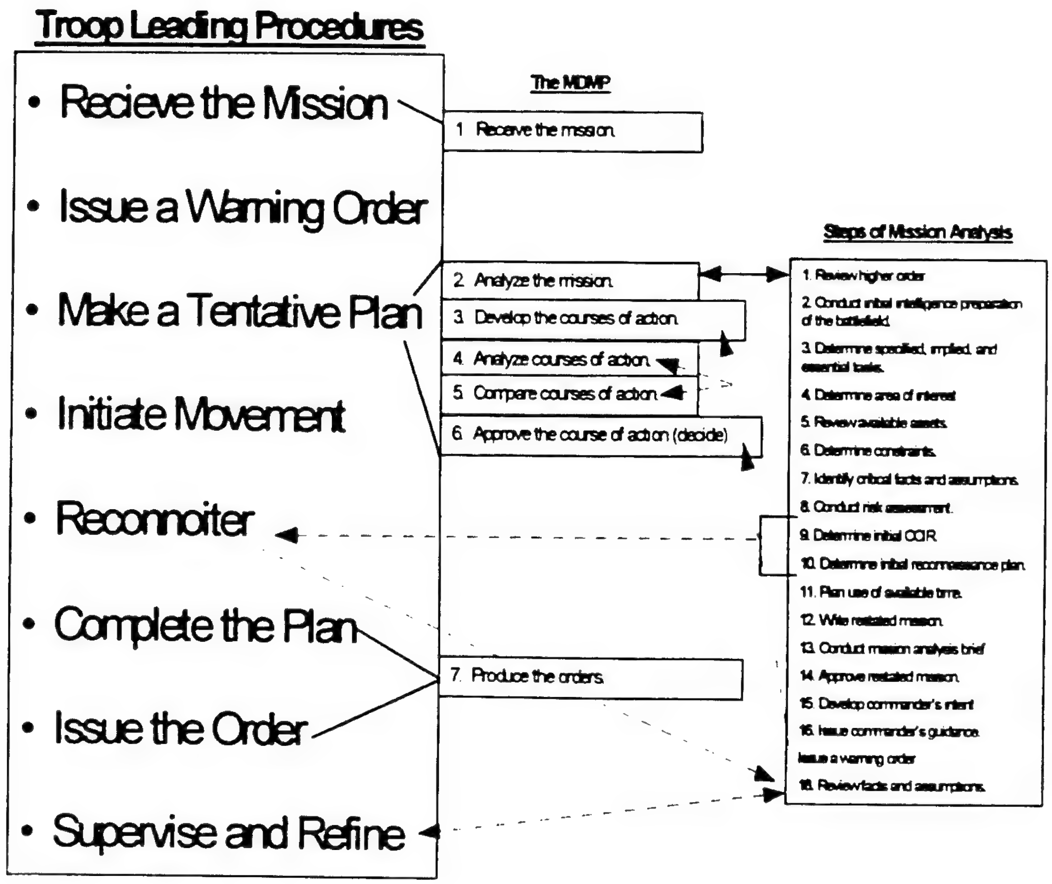

Figure 2. Relationship of the Troop Leading Procedures and the MDMP. sources: Troop Leading Procedures from FM 7-30, *The Infantry Brigade* (Washington, DC: Headquarters, Department of the Army, 1995), I-1, fig. I-1; The MDMP and Steps of Mission Analysis from FM 101-5, *Staff Organization and Operations* (Final Draft)(Washington, DC: Headquarters, Department of the Army, 1996), 5-5 and 5-10, figures 5-2 and 5-4.

the relative strengths and weaknesses of each COA. Secondary products of this analysis further refine each COA into a more detailed plan. These products include, but are not limited to, synchronizing available assets, refining CCIR and reconnaissance tasks, developing options to the COA, and developing decision support templates and matrices (DST/DSM) to assist decision-making during execution. The staff then compares the COAs to each other based on the strengths

and weaknesses and other criteria. These criteria are derived from the commander's guidance, the higher plan, and doctrinal norms. Once the comparison is complete the staff presents their findings and recommendations to the commander to gain his approval on their recommended COA. During step six the commander decides on a COA by determining which COA he believes is best. He may reject or modify the staff's recommendation. If he does modify the staff's recommended COA then the staff must analyze the modified COA to complete the plan.

The Army recognizes that its commanders will often make decisions when sufficient time for the MDMP is not available. FM 101-5 (Final Draft) states that while all steps of the MDMP must be completed some may be abbreviated to shorten the overall process. Three suggestions for abbreviating steps are offered; increasing the commander's involvement in the process, issuing more directive commander's guidance and limiting options, and to limit the number of courses of action developed and analyzed. In time constrained situations the MDMP's goal changes from finding the best course of action to finding an acceptable course of action. FM 101-5 suggests that in extreme situations the commander may direct that the staff develop only one course of action.[22] Essentially the MDMP remains an analytical decision model with varying degrees of commander and staff involvement.

CCIRs allow the commander to limit the amount of information that is sent to him. He establishes the CCIR to support his understanding of the battle and to facilitate critical decisions. CCIRs are established early in the planning and changed as needed to adapt to the dynamics of the situation. The CCIR is composed of three elements; the priority information requirements (PIR), the essential elements of friendly information (EEFI), and the friendly forces information requirements (FFIR). PIRs are the information that the commander determines he needs to know about the enemy to develop, decide on, and implement courses of action. EEFIs are the information that the commander wishes to protect from the enemy. Protecting information about his forces or intentions allows the commander to implement his decisions. FFIRs are the information about friendly forces that the commander requires to determine the feasibility of

courses of action. Understanding the actions, locations, and situations of his own and adjacent forces allows the commander to make reasoned decisions on courses of action.[23] CCIR is the filter provided by doctrine to allow the commander to get just the information that he needs.

The commander and staff develop reconnaissance plans to answer CCIRs, especially PIR. Information gathered during the execution of the reconnaissance plan is analyzed for enemy indicators that answer PIRs. For example, if a PIR is "Will the enemy employ persistent chemical agents to deny his southern flank?" then a report of, seemingly random, heavy artillery fire in the area where the S2 templated the chemical strike indicates that the enemy has fired the strike. Observations of animals dying in that area, enemy units in chemical gear or emplacing markers are further indicators of the enemy action.

Figure 2 shows the relationship between the development of CCIRs; the development, analysis, comparison, and decision on COAs; and the execution of the reconnaissance plan as part of the Troop Leading Procedures (TLP). CCIRs developed during the mission analysis focus the development of the reconnaissance plan. Information gathered during the reconnaissance is used to refine facts and assumptions used during planning. These facts and assumptions are key to the development and analysis of COAs, and therefore, ultimately to the commander's decision. Once the order has been published the reconnaissance continues. The information is analyzed with respect to the plan and revisions to CCIR or to the plan itself are made as appropriate. If the commander discerns a significant difference between reality and the situation his plan is based on, he may begin planning all over. This is what "deducing the mission" means.

This examination of the U.S. Army's doctrine for decision-making provides an understanding of how the Army envisions commanders making decisions. It established that decision-making is a key component of Battle Command, and that commanders are expected to balance centralized and decentralized decision-making through the use of mission tactics. Next, it considered the Army's emerging doctrine for the application of DIS and demonstrated that the hypothesis of the emerging doctrine is that more information will result in faster decisions.

Further, Force XXI leaders are expected to take actions without complete information, but within a common picture of the battlefield. Finally, this section discussed the Army's decision-making model and information filtering system. The next section scrutinizes decision-making theory to allow comparison to the MDMP.

Decision-making Theory

In *Background to Decision Making,* William Reitzel establishes the baseline for all decision-making theory when he states:

> Decisions are choices from among alternatives. Choices are made by individual human beings on the grounds that are compelling to them as human beings. And, while it is true that much decision-making is done in cooperatively organized groups, and that many of the grounds for choices are set by the organization--in military organizations, by directives from a superior--the fact remains that, at the point where a choice is made, an individual human being makes it. Consequently, the individual human response to a problem situation runs through all variations of the decision-making process no matter how formally organized.[24]

Reitzel asserts that key to the choice is the decision makers' expectations of future events that occur as a result of that choice. The expectations are based on the decision makers understanding of the situation and his experiences. Because these expectations occur in the future as a result of current actions, the decision maker has to deal with uncertainties related to those outcomes. Decision makers with little experience in this type of activity are more likely to have unrealistic expectations. Further, in most decision situations, the decision maker will not have all the information he needs to make a certain choice, precisely because the choice results in future events. The decision maker develops assumptions to allow him to make the decision. The decision makers use of assumptions must be balanced by his need and lack of information, and the risk posed by the assumption being false. To minimize these risks decision makers try to use as few assumptions as possible, and test those that are used for validity as soon as possible.[25] When making choices each human brings his own experience as a basis for determining what is possible, what information is needed, and how to proceed.

Reitzel offers a decision-making model to describe how humans make this choice:

1. An individual is confronted with an uncertainty-situation combines two reactions:
    a. an effort to analyze the situation, and
    b. an effort to relate the analysis to his expectations of the future.
2. The psychological process. . . consists of choosing a course of action that will
    a. adjust to the analysed [sic] situation in the way that is most likely to
    b. resolve the uncertainty and satisfy the expectation.
3. This involves creating an imaginary future situation and selecting a course of action that will credibly make the expected situation emerge from the uncertainty-situation.[26]

It is important to note that Reitzel sees the reality of the expected outcome is in the mind of the decision maker. There is no measure of how realistically the selected course of action satisfies the expectation. The decision maker simply feels comfortable with his perception of its results. When the decision makers comfort with the selected course of action meets his analysis of the situation he decides and initiates action. By stating that the decision maker acts once his expectations can be realistically met Reitzel implies that no further analysis is done. Reitzel does not make clear whether courses of action are examined simultaneously or sequentially. However, the selection of the course of action is clearly not the result of an analytical examination of criteria based on a number of choices, but an intuitive examination of the course(s) of action.

The lack of analytical examination of the courses of action is inconsistent with the MDMP. Additionally, Reitzel implies that, unlike MDMP, the decision makers are not seeking the best solution to the situation, but one that will work. If, as Reitzel asserts, organizational decisions are made by individuals responding as individual humans, then the MDMP may not be an appropriate decision model for battalion commanders.

Reitzel goes on to differentiate between types of decision situations. He establishes two types of problem situations that impact on the how decisions are made. The first type Reitzel calls a puzzle; a problem situation that can be solved. The puzzle best solution to the puzzle can be determined by performing calculations or using other analytical methods. Reitzel sees the second type of problem as a difficulty; a problem situation that must be overcome. Dealing with difficulties involves using judgment to make a choice from a range of possible courses of action. While one course of action could be more appropriate in dealing with certain aspects of the

difficulty none are clearly superior to the others in all respects. Further, difficulties often have puzzle elements imbedded in them. This requires the decision maker to solve the puzzle in an effort to find a workable choice to overcome the difficulty.[27] The puzzle within the difficulty represents a compound problem situation.

This type of compound problem situation typifies military problems. Commanders must examine and solve all types of puzzles dealing with such aspects of military problems as lift capabilities, time and space relations, and weapon systems' range and volume of fire limitations. The commander must understand the details of these puzzles in order to make the choice of courses of action to overcome the larger difficulty. The commander relies on his staff--his puzzle solvers--to provide the details and recommendations regarding these puzzles. However, the ultimate responsibility to make the choice belongs to the commander. The commander must "walk a narrow path between the dangers of being overwhelmed by correct answers of his supporting puzzle-solvers and the dangers of ignoring their legitimate contributions in favor of his own professional insights and judgment."[28] By using analytical methods the MDMP supports puzzle solving. Its ability to support the commander's ability to chose between courses of action for a compound problem while simultaneously solving its puzzles is questionable. A deeper analysis of the commander's, human, decision-making versus the organization's puzzle solving is required.

Decision theorists categorize decision-making models in two types; normative and naturalistic. Normative decision-making models seek to find the optimum solution for a given problem. Naturalistic decision-making models focus on how humans make everyday decisions. The key differences between the two types of models is the order in which course of action development and analysis occur, and the qualifications of the course of action. In the normative model the courses of action are developed and analyzed concurrently and then the decision is made. In theory this results in the "best" course of action. In the naturalistic model, courses of

action are developed and analyzed sequentially, with the decision maker settling for the first feasible solution developed.

Normative techniques were originally developed for economic analysis, game theory, and statistical analysis of decision-making; but have since been adapted to numerous applications, including operations research.[29] These decision-making models involve an analytical approach to decision-making including the use of multi-attitribute utility analysis, decision analysis, and Bayesian statistics.

Initially, the decision maker develops a range of options or courses of action. In multi-attitribute analysis the decision maker develops a set of criteria then analyzes courses of action based that a set. The decision maker then compares the results of this analysis given the criteria. Decision makers employ decision analysis techniques to weight criterion in the comparison, making some more important to the final decision. The decision maker chooses the course of action that receives the highest "score" resulting from the analysis.[30] The chosen course of action is the optimum given the criteria and the range of courses of action developed. The MDMP is an adaptation of a normative decision-making model.

Gary Klein developed the Recognition-Primed Decision (RPD) model (figure 3) to describe naturalistic decision-making. Klein conducted his studies over a three year period on decision makers in a variety of environments including U.S. Army combat staffs, tank platoon leaders, and firefighters in urban and wildland situations. The uncertainty and confusion of the decision-making environments, and potential catastrophic results of poor decisions clearly illustrate the relevance of Klein's subjects to battalion commanders. Klein's studies indicated that decisions were made very quickly and often without apparently using an analytical approach.

Klein theorizes that decision makers in crisis situations make decisions by very quickly testing and modifying a series of courses of action until finding one that will work. Decision makers determine the need for decision-making based on a continual assessment of the situation. They compare the developing situation to similar situations in their experience base. They

recognize the situation based on the pattern of its impact on their goals and expectancies, observation of critical cues, or indication of typical actions. The decision maker's goals are essentially his desired endstate. Expectancies, on the other hand, are other outcomes that the decision maker expects as a result of his decision. If the situation does not seem familiar then the decision maker seeks more information and continues his analysis. The decision maker then develops an analogue by determining the closest approximation to this situation in his background and modifying it to fit the situation. After determining the nature of the situation the decision maker analyzes it based on his goals. These goals may not be definable and specific. For example a military decision maker's goal should be to accomplish his assigned task with the minimum casualties. However, during the course of the operation he may determine that it is no longer possible to accomplish his mission in its entirety. Should he continue anyway, should he stop the operation, or should he do some action in between? This type of dilemma is consistent with Reitzel's idea of a difficulty. The decision maker must continually analyze the difficulty as it develops to understand its impact on his expectancies such as culminating the enemy, protecting the force, and facilitating future operations.

The decision maker's goals are linked to this analysis. The decision maker examines the available information to find critical cues for action. This allows him to quickly work through a large amount of information in a short time because he knows what he is looking for. These critical cues aid the decision maker to determine if and when to act. The decision maker links his expectancies to his goals. If actions taken do not produce the expected results within a given time then this indicates that the decision maker's assessment of the situation is not valid. He then returns to the situation assessment and attempts to gain an understanding of the situation. Upon recognizing a situation, determining goals, expectancies, and receiving cues the decision maker sorts through his experience base of typical actions to determine an appropriate action or set of actions. The decision maker imagines each action's outcome given the situation. This mental

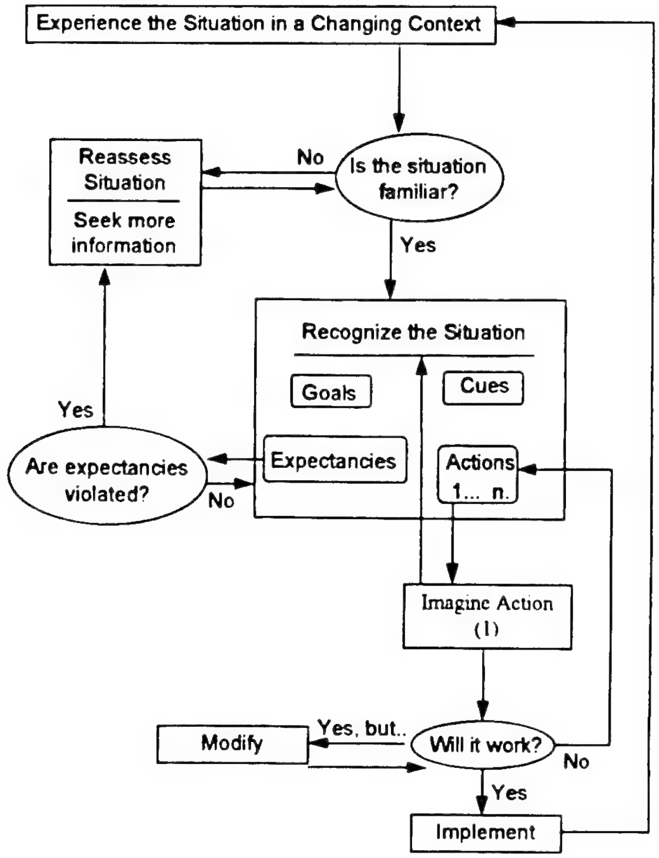

Figure 3. Recognition-Primed Decision Model. source: G.A. Klein and R. Calderwood, "Investigations of Naturalistic Decision Making and the Recognition-Primed Decision Model." ARI Research Note 90-59, Prepared by Klein Associates for the U.S. Army Research Institute for the Behavioral and Social Sciences (Fairburn, OH: Klein Associates Inc., 1990), 7, fig. 1.

analysis is done in serial fashion until a workable solution is found. The decision maker modifies the action, tests it to ensure its adequacy and implements it. Note that the decision maker never compares the courses of action as in the MDMP. The experienced decision maker goes through this process in a matter of minutes, allowing quick decisions and action.[31]

Klein postulates that RPD may be what is commonly known as intuition.[32] A decision maker's ability to make quick, sound decisions based on intuition is linked to that decision makers experience base. The greater the breadth and depth of experience the more likely that the decision

maker will find an acceptable solution within the limitations of the time available. Klein asserts that RPD is not necessarily superior to normative decision-making, but in crisis situations it may allow a decision maker to react more quickly.[33]

Jon Fallesen supports Klein's conclusions about naturalistic decision-making in *Overview of Army Tactical Planning Performance Research.* This study reviews human performance research to develop enhancements to the Army's battle command performance. Fallesen isolates serial analysis and the selection of the first workable solution as attributes of naturalistic decision-making. He discusses the inadequacy of Army doctrinal publications and training that focus on normative decision-making. Fallesen concludes that the MDMP should be modified to support naturalistic rather than normative decision-making.[34]

Klein Associates published a number of papers and articles on their crisis decision-making study during the late 80's and early 90's. Two reports focus on particular aspects of decision-making relevant to this study. These reports are *Investigations of Naturalistic Decision Making and the Recognition-Primed Decision Model* (hereafter referred to as *Decision Model*) and *Recognitional Decision Making: Information Requirements* (hereafter referred to as *Information Requirements*). The reports discuss the ability of decision makers to make quick, sound, decisions using RPD and the information required to make those decisions.

Decision Model describes the overall findings used to develop RPD during Klein's study. These findings suggest a significant difference between the abilities of experienced versus novice decision makers. Experienced decision makers generally focus on assessing the situation to detect action cues. The decision maker moves from the detection of action cues directly to selection of courses of action. Novice decision makers tend to evaluate options first to determine action cues to look for. Normally, novice decision makers notice the same cues as experienced decision makers, but lacking the experience base are unable to develop courses of action relevant to the situation. This is particularly the case in situations that do not match, or nearly match decision makers' experience. These situations require the decision maker to modify analogous situations to

develop the unique solution. The selection of inappropriate analogues are a significant cause of faulty decision-making. Decision makers with a broader, deeper experience base simply have more analogous situations to select from, assisting them in developing the new solution. As a result experienced decision makers are less effected by time pressure.[35] While both expert and novice decision makers employ RPD the expert decision maker is significantly more likely to develop an acceptable solution within the limitation of time.

In *Information Requirements*, Klein addresses RPD given the use of DIS and digital decision-making aids. He asserts that decision-making aids developed to support normative decision maker may hamper expert decision maker's use of RPD. Decision aids that require input in the form of multiple courses of action, decision criteria and weights, and numerical ratings for each criterion interfere with the decision maker's recognition of the situation. Klein states that the development of DIS and digital decision aids should not interfere with proficient decision makers and should assist in the training of less experienced decision makers.

To support that end, *Information Requirements* suggests nine capabilities for DIS that support RPD. The first is that the DIS must support the decision maker's ability to assess the situation both within the context of the information system and from the external environment in which the decision maker is operating. This is critical to the decision maker's ability to understand the dynamics of the external environment and how it is responding to their actions. Next, the DIS should have the capability to highlight action cues, such as the initiation of expected changes or lack thereof. The DIS operator should be able to ascertain the systems reliability or inability to deal with inconsistent data. The DIS should present its data in an image. This is key to facilitating the decision maker's ability to mentally analyze courses of action. This use of analogues to present data results in a loss of precision. The limited ability of the operator to understand alphanumeric data quickly, however, more than justifies the loss of precision. A DIS should allow the operator to input and recall images of courses of action and decisions. Additionally, the DIS could store a data base of typical analogues to assist the decision maker in

developing solutions to unique situations. Finally, Klein suggests that, with the development of artificial intelligence, the DIS could suggest typical responses to highlighted action cues or data trends.[36] Decision makers require information to be formatted in a way that allows them to quickly comprehend it. Visual images that present a generalized picture while allowing interface with the environment best support decision-making.

In summary, exclusive use of MDMP is not fully supported by decision-making theory. If Reitzel is correct then, commanders do not make decisions based on the MDMP in any case. If Klein's decision-making model is correct, or nearly so, then commanders make decisions by selecting the first satisfactory solution they think of given their experience base. Furthermore, military problem situations are often compound in nature with dynamic goals and resisting solutions based on an analytical approach such as MDMP. Therefore, the validity of MDMP to support decision-making in combat is questionable at best.

This chapter examined available literature on the background, doctrine, and theory pertaining to decision-making. It provided an understanding of the Army's battle command doctrine and decision-making process, and an examination of emerging DIS doctrine as embodied by TRADOC Pam 525-5. It resulted in an assumption that commanders in execution do not use MDMP, but a naturalistic decision model. The next chapter explains the methodology used to develop the conclusions of this research.

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CHAPTER 3

METHODOLOGY

The brief examination of literature indicates that the U.S. Army does not fully understand the implications of DIS on commander's decision making during execution. Klein offers a model of crisis, or time constrained, decision making. However, Klein does not fully analyze the utility of DIS in support of RPD. U.S. Army doctrine recognizes the need to limit the amount of information presented to the commander. It does not provide any guidance of how much, or what type of information the commander will need. Both Klein and U.S. Army doctrine recognize that these decisions are made in a highly fluid environment with multiple variables and changing goals. The commander must be able to understand and apply judgment to any piece of information made available to him. If he cannot develop understanding of a piece of information he fails to grasp its meaning. Clearly, the type and quantity of information available to the commander has an impact on his decision making. Too little information and the commander is only guessing; too much, possibly conflicting, information may place the commander in a position where he cannot decide. Information enhances decision making only if the commander can comprehend it and it is relevant to the decision.

When battlefield commanders make decisions they are attempting to influence some future outcome. In order to be relevant, information must indicate some future event or condition that relates to the outcome the commander is trying to influence. Information that predicts a future condition or event possesses a degree of certainty or reliability. For example; the chance that drawing a club from a new deck of cards is 25 percent while the chance that it is the queen of

clubs is less than two percent. A piece of information that indicated that the first card drawn from the deck would be a club is significantly more certain than if it indicated that the first card would be the queen of clubs. The degree of certainty of a piece of information posses impacts on its relevance to the commander's decision. The less certain a piece of information is the less relevant because the commander cannot count on it to predict future events.

How accurate and precise a piece of information is also bear on its relevancy. The degree of accuracy of a piece of information is how true it is. If an observer sees that the queen of clubs is on the top of the deck then his information is accurate, as long as he knows what the queen of hearts looks like and he is known to be truthful. The precision of a piece of information deals with how specific or defined it is. The "queen of clubs" is a more precise piece of information than "a club face card," which is more precise than "a club." Commanders require that information be both accurate and precise enough for them to make their decisions.

Expanding on the deck of cards analogy illustrates the three qualities of information. A gambler is betting on the first card dealt from a new deck of cards. He has received information from a trusted colleague that the top card in the deck is the queen of clubs. His information is both accurate and precise. If his colleague has just seen the deck of cards he can be almost completely certain that the first card is the queen of clubs. The gambler can place his bet with confidence. If the colleague saw the queen of clubs on top of the deck cards a week ago then the gambler is uncertain about the outcome of his bet.

This analogy is easily applied to combat. The gambler is the unit commander who must decide between courses of action. His colleague represents the variety of sensors and reconnaissance assets available to him. The dealer represents the enemy commander. There are a number of weaknesses to this analogy. First, the terrain has no impact in the analogy, whereas in combat the terrain can have a major impact on decision making. In the analogy the dealer has to play by an established set of rules. In combat an enemy commander is loosely tied to his doctrine,

his set of rules. However, the analogy does facilitate an understanding of how to analyze the impact of DIS on decision making.

First, the analysis focuses on the gambler's colleague, or rather, the ability of DIS to collect and transmit the available information to battalion commanders. It assesses the qualities of the information provided to determine if it is accurate, precise and certain. The analysis should examine a fourth quality of information--its timeliness. The timeliness of a given piece of information is relative to the action the commander wishes to take. Generically speaking, in order to be timely a given piece of information must reach the commander with enough lead time so that he can decide, communicate his instructions, and act before the event which he is trying to influence occurs. In the case of the gambler analogy it does the gambler little good if he receives a positive identification of the card to be played after he has placed his bet. Therefore the first part of the analysis focuses on accuracy, preciseness, timeliness, and certainty of information provided by DIS to battalion commanders.

Next, the analysis focuses on how the gambler determines which bet to place, or rather how the battalion commander decides which course of action to pursue. This section considers the inter-relation of RPD with applicable portions of the MDMP. It considers the findings of the first part of the analysis to determine how the quality of the information provided by DIS supports or fails to support the commander's decision making. Further, it gives an indication of the relevance of the amount of information available for the commander to consider.

Finally, the analysis focuses on those elements that the gambler, or commander, does not control. At this point the analogy becomes significantly less useful. While the gambler cannot be sure that the dealer will play by the rules, he is relatively certain that the table will not impact on his bet. Further, the gambler knows that the "best" outcome of his chosen course of action is to maximize his earnings. The combat commander cannot be certain that the enemy commander is under any requirement to use his doctrine. Even if the enemy does employ his doctrine, the commander cannot be certain of how that application of the enemy doctrine will occur. The

commander must manage the impact of terrain and weather to lessen its degradation of his chosen course of action. While terrain analysis and weather analysis will provide him with a solid understanding of what impacts might occur he can never be certain of those impacts until they do occur. Additionally, the commander can never be sure what the "best" outcome is. Combat actions have cumulative effects and a signal victory today could place his forces at a disadvantage tomorrow. The final part of the analysis focuses on these and other aspects of the environment of combat that are beyond the commander's ability to control.

The commander's understanding of the environment and actors of his combat situation are key to his development of a mental image, or database, that allows him to make decisions. He gains this understanding by assimilating information from a variety of sources. DIS facilitates this understanding by providing a high volume of precise information. Hence, this chapter describes the method developed to verify or refute the following hypothesis: <u>Current and developing DIS enhances a battalion commander's decision making during execution by providing high volumes of accurate and precise information that reduces his uncertainty</u>.

This method involves four steps. First is an analysis of the capabilities of current and developing DIS systems to provide accurate and precise information. The analysis focuses on the objective capabilities of FBCB2 and ASAS to provide accurate and precise information. While current versions of FBCB2 and ASAS may not be able to meet the objective capabilities, considering objective capabilities allows for future technical development. Next is an analysis of the requirements for accurate, precise, and certain information in combat decision making. The final analysis is of the degree of certainty of any information in the environment of combat. This allows an understanding of the relative value of precise and accurate information for combat decision. The last step of the methodology is to fuse the findings of the first three analysis's and develop a set of inferences and general conclusions concerning the established hypothesis. While this set of inferences cannot positively verify or refute the hypothesis they provide a point of departure for future research and analysis.

Analysis of DIS Capabilities

This analysis consists of three parts; information on the terrain and weather, information on the enemy, and information on friendly forces. Each part analyzes the precision and accuracy the information provided by the ASAS and FBCB2. The organization of this analysis generally follows the pattern established by the MDMP for mission analysis. Mission analysis attempts to manage, analyze, and present to the commander all the relevant information on the terrain and weather, enemy, and friendly force. ASAS provides information on enemy forces and terrain within the area of operations of the battalion. FBCB2 provides position location of friendly forces and facilitates the transfer of all information between elements of the friendly force. Understanding the precision, accuracy, and timeliness of the information provided by these two systems is essential to discerning their impact on the commander's decision making.

Analysis of Combat Decision Making Information Requirements

This examination of decision making incorporates elements of the MDMP and RPD. First, it compares the two decision making models to determine how information flows to the commander for his assimilation. Second, it analyzes the what information is required by decision makers to enable them to make decisions. This analysis establishes information requirements and their relationship to decision making cues.

Analysis of Certainty in Combat

The final analysis examines the environment of combat to establish its effect, if any, on decision making. This analysis has two parts. The first part establishes the nature of the combat environment. The second part compares the nature of combat to the information requirements established during the second step of the methodology. This comparison establishes the effect of the nature of combat on decision making.

In summary this chapter described the method used to analyze information relevant to the hypothesis: Current and developing DIS enhances a battalion commander's decision making during execution by providing high volumes of accurate and precise information that reduces his uncertainty. The final step of the methodology is the synthesis of the findings. This synthesis provides insight for future analysis and research to verify or refute this hypothesis.

The next chapter describes the environment of combat as a precursor to the third step of the analysis. This description establishes how the nature of combat effects the certainty of information. Additionally, the description explains generically how humans try to deal with these effects.

CHAPTER 4

THE ENVIRONMENT OF COMBAT DECISION MAKING

This chapter describes the environment of combat as it is relevant to decision making. This description supports the analysis discussed in the last chapter by establishing psychological influences that exist in combat. The overall effect of these influences is to create uncertainty in the mind of the commander. DIS seeks to mitigate this uncertainty by providing high volumes of accurate, precise information in a timely fashion. Hence, understanding the sources of uncertainty as it exists in combat is essential to studying the impact of DIS on battalion commander's decision during combat operations.

This description has three parts. The first part is a description of complex systems. This description facilitates developing an understanding of the psychological influences of the combat environment. Next is a description of combat in general. This establishes that combat is a complex system. Finally, this chapter examines theories that describe the psychological influence of understanding complex systems. These theories establish the way in which humans deal with complex systems, and therefore illuminate the effects of the combat environment on decision making.

Complex Systems

The science of complexity is a relatively recent attempt by physicist and economists to refine their understanding of what makes things happen in systems that result from the inter-

action of numerous, seemingly unrelated, non-linear sub-systems. Until the early 1980's these complex systems were either not regarded as a "system," or were approached from the stand point that the right "cause and effect" had not been discovered. Complexity differs from the widely accepted scientific thought process, Newtonian science, in that it does not seek to explain results in terms of specific causes.

In Newtonian science every event that occurs within a system should have a traceable set of causes that allows the scientist to determine the cause of the event. Understanding this traceable cause enables a scientist to reproduce the same result, or predict its occurrence in another similar situation. The Newtonian scientific method seeks to control variables in order to isolate and measure the cause and effect relationships. This method relies on a systems linearity; its proportional and additive nature. Proportionality refers to an equal output for every input to the system. The additive nature is simply a system as a whole is equal to its parts added together. Once the scientist understands the interaction of the systems components he can predict the effect of external forces by applying the measure of that force to the systems proportionality. Unfortunately this type of thinking has limited value when the system has nonlinear components.

In systems that exhibit nonlinearity proportionality and additivity are invalid. In nonlinear systems the whole can be greater than the sum of its components. Mitchell Waldorp describes music as exemplifying this property in *Complexity: The Emerging Science at the Edge of Order and Chaos*. He states that sound is a linear system. As such, two different musical instruments produce sounds that are distinct and can be identified from one another when played together. However, the interaction of those sounds and the human ear are indicative of nonlinearity:

> Our brains certainly aren't linear: even though the sound of an oboe and the sound of a string section may be independent when they enter your ear, the emotional impact of both sounds together may be very much greater than either one alone.[1]

While science is certainly not unaware of this type of nonlinearity, understanding it is nearly impossible.

Before the development of the science of complexity, science dealt with nonlinearity by applying linear approximations for these variables. Scientists felt that eventually the true nature of these variables would be discovered.[2] The development of computers allowed scientists to incorporate nonlinearity into experiments through simulations. The result was a growing realization that small deviations in nonlinear systems, such as the atmosphere, could create effects all out of proportion to the deviation. The analytical methods of Newtonian science were unable to explain these phenomena.

In the science of complexity, systems are examined as a whole, as opposed to the reductionist methods of Newtonian science. This new scientific method focuses on the complete system.

> Complexity demands analysis at the macroscopic, rather than the microscopic, scale because it is a consequence of interactions between many units whose properties in isolation tell us virtually nothing about important global behavior.[3]

However, not all systems are immune to Newtonian science. Only those systems that exhibit nonlinearity and the ability to evolve can truly be termed complex. The science of complexity, as explained by Peter Coveney, deals with: "the behavior of macroscopic collections of such units that are endowed with the potential to evolve in time."[4] What are complex systems? As an example consider all life forms, they adapt to a changing environment yet retain their individual identity.

Complex systems differ from chaos in that they are adaptive and self-organizing. Chaos exists where there is nearly a complete lack of order. Adaptation and organization are impossible because of the ever changing nature of the variables. Not much gets done in terms of organizations or systems.[5] The closer one gets to complete chaos the greater the degree of uncertainty. Complex systems function best when they are poised between the margins of order and chaos.

> Complex adaptive systems, in a never ending process of adaptation and coevolution, through emergence and natural selection, bring themselves to the edge of chaos...It means being poised in a dynamic balance with sufficient nonlinear freedom to enhance creativity, novelty,

> entrepreneurship, risk taking, experimentation, and discontinuous change while not drowning in totally chaotic confusion and uncertainty.[6]

The idea of coevolution is related to competition. The competing systems force one another to adapt or perish. Further, systems may cooperate to maximize their adaptive natures.[7]

In summary, complex systems adapt and evolve in an effort to deal with the uncertainty associated with chaos. Because of their nonlinear nature these systems defy analytical examination of Newtonian science. Scientists attempting to understand complex systems employ a holistic approach, analyzing subcomponents only as they affect the system as a whole.

Combat as Chaos

Consider combat as a system. The collision of two or more entities bent on trying to destroy the other. Almost by definition the object of combat is to place the opponent in chaos, or the complete lack of order. In order to deal with this force moving them towards chaos armies must be complex systems. They must be able to adapt to the changing environment and operate nonlinearly.

In *On War*, Clausewitz establishes the idea of "fog" or "friction" in war. He describes war as an environment where nothing occurs as it was foreseen by the participants. Clausewitz stated that the primary cause of this friction was chance. Of chance Clausewitz writes:

> War is the providence of chance. In no sphere of human activity is such a margin to be left for this intruder, because none is so much in constant contact with [chance] on all sides. [Chance] increases the uncertainty of every circumstance, and deranges the course of events.[8]

Friction was created by that the interaction of many small units, often acting at cross-purposes; its result was uncertainty. Clausewitz's description of friction and chance clearly imply that combat is nonlinear and complex in nature.

Intuitively, Clausewitz recognized combat's chaotic nature and explained the act of war making as neither an "art" nor a "science."

> We say therefore war belongs not to the province of Arts and Sciences, but to the province of social life...instead of comparing it with any Art, to liken it to business competition, which is also a conflict of human interests and activities; and it is still more like State policy...Besides,

> State policy is the womb in which war is developed, in which its outlines lie hidden in a rudimentary state, like the qualities of living creatures in their germs.[9]

In comparing warfare to a living being, Clausewitz establishes combat's nature. This recognition of combat's chaotic nature was particularly insightful given that Clausewitz lived in a time when Newtonian science was being applied to all facets of human endeavor.

Because of his understanding of the nature of war Clausewitz rejected the reductionist techniques espoused by other military theorists of his age. He advocated a more holistic approach to the analysis of combat that avoided isolating variables in search for cause and effect relationships.

> But in war, as generally in the world, there is a connexion [sic] between everything which belongs to a whole; therefore, however small a cause may be in itself, its effects reach to the end of the act of warfare, and modify or influence the final result in some degree...In the same manner every means must be felt up to the ultimate object.[10]

Clausewitz suggested that there was value in the application of standard tactical methods, particularly for small units. However, he realized that on the whole combat was too complicated to be reduced to a set formula.

Clausewitz's requirement for standard methods while espousing a holistic approach to problem solving illustrates the paradox of military decision making. Recall Reitzel's idea of a puzzle versus a difficulty and the compound problem situation as discussed in chapter two. Most military problem situations will have aspects that require puzzle solving-hence, reductionist analytical analysis and the use of standard techniques. Additionally, the military problem situation will have difficulties that require an ability to understand and deal with non-linear systems and complex, adaptive organizations to overcome. Further, the military problem situation will have aspects that require a non-linear reaction without allowing time for any decision making. Consider a unit conducting a tactical road march. The development of road march tables and orders represent the puzzle solving. The organization of march units to deal with enemy actions enroute and after arrival, and to facilitate future operations represent the difficulty. The actions of

the unit when ambushed illustrate the need for non-linear standard reactions. After encountering the ambush, the commander is faced with a new set of difficulties to overcome while continuing to deal with the original set. Clearly, combat will force the commander to deal with an ever increasing set of compound problem situations--the "fog" and "friction" of war.

Clausewitz's discussion of "fog" and "friction" establishes the combat environment as chaotic in nature. In combat the commander struggles to understand and influence this environment. In an effort to find or create certainty within his own operations the commander uses a set of rules or doctrine. However, the commander's efforts fall short at every turn because of this "fog" or "friction." Often this friction is the result of his own units actions as things do not happen as the commander foresaw. Alternatively, the enemy induces friction by acting or reacting in a way that the commander had not prepared to deal with. To correct his understanding of the environment the commander attempts to control what he can and observes what he cannot. Observing the environment to determine its reality allows the commander to adjust his plans, thus lessening the effects of uncertainty. To be successful in this environment armies must be complex, adaptive, systems. Anything less would quickly devolve into chaos or be paralyzed in indecision and destroyed. The art of war is in itself an effort to adapt and evolve towards a goal even as the environment moves towards chaos. The next section examines a theory that relates to these efforts at setting and managing these goals in this chaotic environment.

Dealing with Chaos

How do humans, and hence commanders, manage the impact of chaos? If a commander's plan never matches reality, how can he ever hope to achieve his objective? John Boyd theorizes that humans adapt to their chaotic environments using a cyclical planning process he calls "Creation and Destruction." He describes the development of a concept of reality as a process where a situation, or set of domains, is analyzed to determine its constituents. Once the constituents have been identified the concept developer imagines them de-linked from their

original context or domain. This process is destructive deduction, or simply destruction. The concept developer then links these constituents back together in a new pattern to establish his new concept of reality. This is constructive induction, or creation.[11] This is precisely to process used by the MDMP. The planner first analyzes the mission and higher order, the terrain and weather, and the enemy situation to gain an understanding of the particulars of these three domains. Having done that the planner then reconstructs them back together using a new pattern to establish his concept for the operation. Thus, by analyzing a complex situation enough to allow the planner to understand is constituents the planner is enabled to construct a new concept of reality.

However, one of the properties of complex systems is its ability to adapt. How can the concept developer ensure that his new concept will match reality? Boyd argues that the concept developer must now examine and compare the concept against the domain of reality to test its validity. In this sense the concept developer compares his new concept with each of the domains that made up the original situations. He repeatedly tests the concept against each domain's constituent parts to ensure the concept matches reality and will work.

> Such repeated and inward-oriented effort to explain increasingly more subtle aspects of reality suggests the disturbing idea that perhaps, at some point, ambiguities, uncertainties, anomalies, or apparent inconsistencies may emerge to stifle a more general and precise match-up of concept with observed reality.[12]

The concept developer has no choice but to assume that his new concept will not match reality. He cannot ensure his concept is valid without inquiring into reality as it now exists.

To that end the concept developer uses the concept to design his future observations of reality. The design of these inquiries, or observations, is such that they detect differences between reality and the concept. The results of the observations are then used to refine the concept to bring it into closer alignment with reality. Further inquiries are developed based on this refined concept and the observation begins anew. The result is that the concept is ever changing and always approaching, but never reaching, perfect consistency with reality.[13]

The problem with this approach to dealing with complex systems is that they adapt to the actions of the observer. Consider Heisenburg's Uncertainty Principle. This principle set forth by Werner Heisenburg in 1927 postulates that one cannot simultaneously precisely fix the position and momentum of a sub-atomic particle.[14] In general it states that the more closely a sub-atomic particle is observed the more uncertainty or erratic behavior is perceived by the observer. This is because the techniques used to observe the particle in detail influence its behavior, so an observer can never be sure of the particle's behavior. Boyd uses the Uncertainty Principle to explain why a concept developer who attempts to conduct ever more precise inquiries into reality get ever more uncertain results. This is because in his attempt to gather more precise observations the observer intrudes into the domain of reality inducing a change in behavior. The greater the degree of intrusion, the more the uncertainty perceived in the observation.

> In other words, the uncertainty values not only represent the degree of intrusion by the observer upon the observed but also the degree of confusion and disorder perceived by that observer.[15]

This means that the observer can never be sure if the behavior of the observed is genuine or induced as a reaction to the observer's actions.

Boyd advances a third part of his theory which he relates to the Second Law of Thermodynamics. The Second Law of Thermodynamics basically says that systems tend to move from order to disorder. Boyd uses the law to describe how any system naturally generates uncertainty, confusion, and disorder.[16] This means that the observer's system, or concept, moves towards disorder even as the observations of reality are being made.

Boyd's use of Heisenburg's Uncertainty Principle and the Second Law of Thermodynamics is consistent with complexity even though both of these are linear approximations of non-linear phenomena. These two Newtonian constructs appear to contradict each other. With the Second Law of Thermodynamics stating that systems exhibit decay from a macro point of view, while the Uncertainty Principle implies that one can only discern order in a microcosm when viewing it from a more general position. However, they were developed to

describe different aspects of essentially the same phenomenon. That is, the tendency for things to act differently from what science expected. Boyd, writing from a time just before the advent of complexity, uses these two constructs to illustrate the effects of complexity.

Summarizing Boyd's analysis thus far generates three ideas. First, that a concept of reality must be compared with reality to determine its consistency with that reality. The comparison refines the concept so that it approaches, but never reaches perfect consistency with reality. Next, the act of comparing the concept with reality distorts reality. Further, this distortion increases in direct proportion to the level of detail of the comparison. Finally, the new system, or concept, decays towards confusion while the comparison is being made. An example of these ideas clarifies Boyd's thinking.

Consider a naturalist studying a type of gorillas in the wild. He has studied gorillas in captivity and analyzed their behavior. He has studied and analyzed the results of other's research on gorillas and other primates. He analyzes the environment in which these particular type of gorillas live. From these analyses the naturalist has developed a theory, or concept, regarding gorilla behavior in the wild. To test his theories he must observe the gorillas in their natural habitat. As he observes their behavior he refines his theories and develops a new observation plan, requiring him to get closer or otherwise be more intrusive into the gorilla's habitat. However, the gorillas change their behavior because of his more intrusive presence in their habitat. What is more important is that the closer he attempts to get to the gorillas, the more their behavior changes. Additionally, the remote sensors that he has installed to monitor gorilla behavior begin to give false or faulty observations, resulting from exposure to the elements, other animals, and the like. In the end the naturalist writes a book on gorilla behavior, but can never be certain that the behavior he observed is how the gorillas behave when he is not there. It's a little like the age old question about a tree falling in the woods.

However, Boyd offers a solution. He suggests that when the concept developer determines that his comparison begins to show increasing tendency toward disorder he simply

"destroys" his concept and "creates" a new one. "Simply stated, uncertainty and related disorder can be diminished by the direct artifice of creating a higher and broader more general concept to represent reality."[17] The concept developer must work with more general concepts to lessen the impact of uncertainty in complex systems. Generalities allow him to understand the relationship of his concept to the environment. In other words, maybe it's better to believe that a theory gorilla's behavior is correct than to add uncertainty by trying to prove it. There is no need to determine if a tree in the woods makes a sound when it falls if no one is around because everyone believes it does.

Boyd's conclusion conforms with the science of complexity. His emphasis on general concepts of reality is equivalent to complexity's requirement for holistic examinations of systems. Boyd realizes that continued analysis can lead to erroneous conclusions as the effect of uncertainty rises. Similarly, complexity scientists deplore over-analysis and the isolation of variables as these techniques change the outcome.

In summary this chapter examined the new science of complexity, compared combat to chaos, and described a technique of dealing with the effects of complex, adaptive systems in a chaotic environment. This examination showed how complex systems adapt and evolve to deal with the uncertainty of chaos. It described combat and demonstrated how it approached chaos, thus requiring that armies be complex, adaptive systems to survive. Finally, this chapter described in detail how general concepts allow concept developers to mitigate the effects of complex, adaptive systems in chaotic environments. The next chapter analyzes DIS capabilities, information requirements for decision making, and the effect of certainty in combat decision making. This chapter's examination supports the analysis of the effects of certainty in combat decision making.

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[1]M. Mitchell Waldorp, *Complexity: The Emerging Science at the Edge of Order and Chaos* (New York, NY: Simon and Schuster, 1992), 65.

[2]Uri Merry, *Coping with Uncertainty: Insights from the New Sciences of Chaos, Self-Organization, and Complexity* (Westport, CT: Praeger, 1995) 22.

[3]Peter Coveney and Roger Highfield, *Frontiers of Complexity* (New York, NY: Fawcett Columbine, 1995), 192.

[4]Ibid., 7.

[5]Waldorp, 312.

[6]Merry, 195.

[7]Waldorp, 292-294.

[8]Carl von Clausewitz, *On War*, ed. Anatol Rapoport (London: Penguin Books, 1982) 140.

[9]Ibid., 202 and 203.

[10]Ibid., 214.

[11]John R. Boyd, "Creation and Destruction," Command and General Staff College Advance Book for A391 (Fort Leavenworth, KS: US Army Command and General Staff College, 1976) 3-4.

[12]Ibid., 5.

[13]Ibid., 7.

[14]Robert C. Weast, ed., *CRC Handbook of Chemistry and Physics*, 58th edition (Palm Beach, CA: CRC Press, 1978) F-107.

[15]Boyd, 9.

[16]Ibid., 9.

[17]Ibid., 11.

CHAPTER 5

ANALYSIS

This chapter analyzes, interprets, and makes inferences about the information discussed in the previous chapters. The first section discusses the objective capabilities of current and developing DIS to provide accurate and precise information. Then the discussion shifts to the commander's requirements for information in support of decision-making. The last section of the analysis examines the certainty of any information in the combat environment. These analyses support the development of inferences and general conclusions relevant to the hypothesis.

DIS Capabilities

This section analyzes the ability of FBCB2 and ASAS to provide precise and accurate information to the commander. This allows the reader to evaluate the overall effects of DIS when compared with the second and third sections of this chapter.

ASAS, the first system to be considered is a tool to assist in intelligence information management and access. Normally, there will be one ASAS per battalion, located in the main command post.[1] It provides information gathered by collectors throughout the battlefield to include up to national level, space-based imagery systems. This information may come as video or still picture imagery; signals and communications intelligence, including direction finding and intercept; access to terrain and weather data bases and information like satellite imagery; and contact reports from units throughout the division zone.[2]

Most of these collectors are not responsive to requests by the battalion to reorient to specific information requirements of the battalion commander. Therefore, the battalion only receives what others are looking at unless they control the asset. Normally, the only asset that is responsive to the commander is his scout platoon or other organic maneuver assets used in the reconnaissance role. The battalion may influence collectors that are supporting the brigade if they are the main effort or the most critical supporting effort.

The ASAS can pass information to subordinate commanders over the FBCB2. One FBCB2 will normally be assigned to each command post, maneuver company, and special platoon. This allows the battalion commander to quickly share information made available to him from any of the sources to which ASAS is linked to. The FBCB2 - ASAS link can also be used to pass information analyzed by the battalion's intelligence officer. Systems linked to the FBCB2, such as the Inter-Vehicular Information System (IVIS) and the Dismounted Soldier System Unit (DSSU), can pass information back to the ASAS. In the future the Lightweight Video Reconnaissance System will pass live video imagery to the ASAS through the FBCB2. Currently this system requires a separate link to the main command post to pass information.[3]

Each of these systems, whether the theater's Joint Surveillance Target Attack Radar System (JSTARS) or a soldier with a DSSU, has an associated degree of accuracy and discreteness. Systems like the DSSU and IVIS that require soldiers to input data potentially have a significant risk of passing inaccurate information. Regardless of how the information gets into the system, though, the DIS will not induce any further error. Thus, the information provided by the DIS, specifically the ASAS and FBCB2, is as accurate and precise as the collector.

Consider the position-navigation (POSNAV) systems. These systems, such as the Global Positioning System (GPS) and the Enhanced Position Location Reporting System (EPLRS), normally have some inherent error. These systems are linked through the FBCB2 back to the main command post. Normally, the error involved is insignificant, but the DIS can induce significant uncertainty as a result of this error. For instance, a tank equipped with an IVIS and

GPS linked through FBCB2 uses its laser range finder to determine the position of an enemy vehicle. The minor error inherent in the GPS is induced into this enemy position and transmitted higher. A second tank, similarly equipped, lases the enemy and reports higher. The second tank's message has its own error induced by the GPS. The result is that the reports identify enemy tanks in two different locations. While this seems fairly easy to mitigate, consider the situation when 20 tanks begin reporting on an enemy battalion. The problem escalates exponentially. However, this study assumes that all the equipment works perfectly with no inherent error.

If there are no errors are made by the equipment and no errors are made by humans interfacing with the DIS then the information provided is both accurate and precise. It is precise because the DIS systems are very discrete. This is especially true of systems that are imagery intelligence based. Even theater systems like the JSTARs report individual target vehicles.[4] Similarly signals and electronic intelligence information identify individual emitters. Therefore, the information provided by DIS is very precise -- down to individual targets.

In the final analysis of DIS capabilities it is clear that the systems are designed to produce, and capable of producing, accurate and very precise information. This study will examine the effect of this on combat decision-making in the third section of this chapter. The next section focuses on identifying what information commanders need to make decisions.

Information Requirements for Combat Decision Making

This section discusses the commander's requirements for information to support his decision-making. It considers both the MDMP and RPD as valid decision-making models, but establishes the primacy of RPD for during execution decisions. The analysis focuses on the need for accurate and precise information to determine the relative value of DIS. This analysis is required to determine what information commander's need, how they establish filters to limit information, and how the information initiates the commander's decision.

MDMP vs. RPD

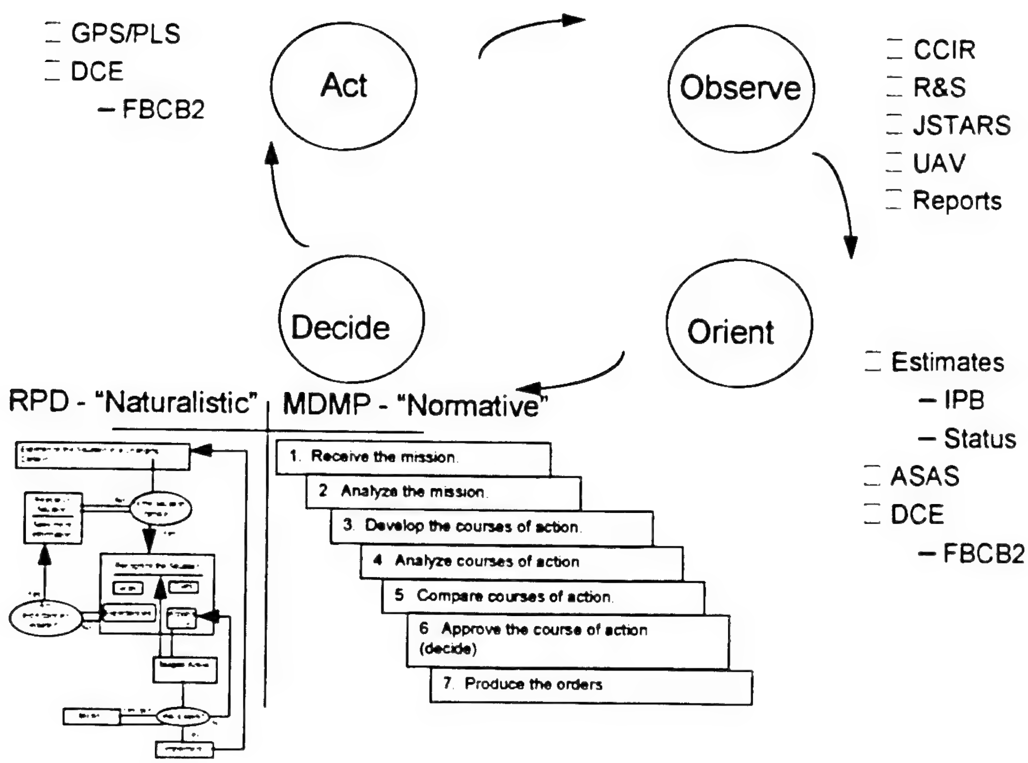

Figure 4. MDMP compared to RPD within the Boyd Cycle, sources: MDMP (lower middle) from FM 101-5, *Staff Organization and Operations* (Final Draft)(Washington DC: Headquarters, Department of the Army, 1996), 5-5, fig. 5-2; RPD (lower left) from G.A. Klein and R. Calderwood, "Investigations of Naturalistic Decision Making and the Recognition-Primed Decision Model," ARI Research Note 90-59, Prepared by Klein Associates for the U.S. Army Research Institute for the Behavioral and Social Sciences (Fairburn, OH: Klein Associates Inc., 1990), 7, fig. 1; Boyd Cycle (upper middle) from NDP 6, *Naval Command and Control* (Washington DC: Office of the Chief of Naval Operations, 1995), 18, fig. 2-1

As discussed previously, MDMP and RPD represent two different schools of thought on decision-making. MDMP is a normative process that seeks to determine the optimum solution to a given problem through the conduct of a careful analysis of the situation and subsequent analysis and comparison of several courses of action. RPD is a naturalistic process in which the decision maker is attempting to find an acceptable solution quickly involving a rapid pattern recognition process where the decision maker selects a course of action based on his experience with similar

situations. Comparing these two (figure 4) processes in terms of the Boyd cycle, the "OODA Loop," highlights the differing requirements for information the decision maker requires in each process.

Note that the observe, orient and act elements of the Boyd cycle are technically external to the actual act of decision-making. Some portions of both models occur within observe and orient: specifically steps one and two of the MDMP and part of situation recognition for the RPD. Essentially, though, the unique portions of the decision-making models are isolated within decide. Given then that the two models consider the decision-making component of the MDMP in isolation.

Steps three, four, five, and six are the actual decision-making component of the MDMP. This requires the commander to analyze, or "destroy," the situation he is in and gain an understanding of it at its constituent level. Having completed that the commander, or his staff, must then reassemble these constants into a new pattern to develop a new course of action. This process of synthesis, or "creation," is conceivably time consuming. The MDMP requires that the commander develop more than one course of action, so he must then synthesize at least one other unique course of action. This requires even more time. During the time it takes for the commander to complete these steps the environment is continually changing and evolving into new patterns. The result is that by the time a commander has analyzed, compared, and made a decision on a course of action it is already based on obsolete information. This change in the information may affect the course of action which is seen as the optimum, even if it could be determined from the base information. The staff's ability to assist the commander is limited and requires additional time even if the commander has some means of assembling and communicating with them. Therefore, MDMP is not an effective tool for making quick decisions as would be required by a battalion commander during the execution of an operation. The US Army has recognized this deficiency and has developed a number of techniques to mitigate the time consuming nature of MDMP in support of decision-making during execution.

The first technique is the use of the CCIR and the DST/DSM. This technique is an attempt to make a decision, or at least develop a course of action, to address the changing battlefield before the changes occur. Developed during the pre-operation planning as a product of the course of action analysis, the DST/DSM is limited by the information and assumptions used during that planning. While this process may develop an acceptably accurate prediction of the types of events that may occur its efficacy in establishing the best course of action to take in response to those changes is questionable. Given the chaotic nature of combat it would be nearly impossible for a commander to foretell what will be the best course of action in response to a change when he has not even made contact with that enemy. Any difference between the enemy's actions and the commander's preconceived idea of their actions causes a deviation in the time, place, and actions required as a result of the commander's decision. Enemy and friendly actions combined will potentially change the compositions of friendly forces and cause a deviation in their capabilities. For example, consider a planned contingency for a company in a defense. The company defends a battle position as part of the base plan. It is supposed to reposition to counter-attack by fire an enemy force if a certain set of conditions, the CCIR, are met. In the event, a number of these conditions may be met and the situation may require that the commander make this decision. However, in the mean time this company has been affected by enemy actions, maintenance failures, and its own actions (such as the expenditure of ammunition and repositioning of forces within its position). The company's capabilities are different from what the commander envisioned. Committing them to this fight further degrades their combat power and may not achieve the desired end. These deviations in friendly capabilities cannot be accurately predicted in planning, limiting the usefulness of the DST/DSM in pre-determining the best course of action in response to changes on the battlefield. In the end, commanders are forced to make major changes from the planned DST/DSM actions to accomplish their desired ends. Normally, this decision will be made under extremely time sensitive conditions.

Another time saving technique suggested by the MDMP is for the commander to develop only one course of action, settling for a workable solution. If the commander develops only one course of action then he performs steps three and four of the MDMP only once, instead of once for each course of action. The purpose of step four, course of action analysis, changes slightly. It is no longer necessary to analyze the course of action in detail to allow comparison based on a previously established set of criterion. However, the commander must fully explore the nuances of the course of action to ensure that he has thought of all the applications of forces at his disposal. This mental visualization is essential in refining the course of action. Step five is no longer required because there is no comparison to make. The decision step takes on a different role. If there is only one course of action then a decision on which course of action to use is not required. So what is the commander deciding on in step six if he is not choosing between courses of action? It can be assumed that he is deciding if this course of action is acceptable. Therefore, the single course of action use of MDMP consists of these steps:

1. Determining that a decision is required.

2. Comparing the new situation that requires this decision to the original situation and ends to be achieved. Modifying those ends as necessary.

3. Developing a course of action that deals with the new situation while accomplishing, or allowing the accomplishment of the original ends.

4. Visualizing the actions required by this course of action to achieve the desired ends and making modifications to it as required.

5. Deciding whether this course of action acceptably accomplishes those ends. If so, implement. If not, develop a new or refined course of action.

Comparing these steps with the RPD in figure 4 yields a conclusion about how commanders make decision in combat. These steps are functionally the same as the steps of RPD. Therefore, commanders essentially use RPD when faced with decisions in "extreme situations." Given the

nature of combat, especially for units at battalion level, it can be assumed that the majority of decisions made by commanders during execution are made in this condition. Therefore, this study assumes that battalion commanders make the majority of their decisions during execution using RPD and not MDMP.

Having established the primacy of RPD for during execution decision-making an examination of this model yields the type of information that commanders need to make decisions. Recall the discussion in chapter two on Klein's *Information Requirements*. In Information Requirements Klein stresses the requirement a system that highlights action cues to initiate decision-making. These action cues are an alteration in the environments' pattern that indicate a changing situation. In this case the pattern is the pattern established as a result of the enemy's operations. MDMP is also concerned with the identification of changes in enemy patterns. The development of CCIRs, specifically PIRs, is tied to a recognition of changes within enemy patterns. In effect then, CCIRs are or should be, the action cues for commanders' decision-making. This holds for FFIRs as well. Commanders analyze information on both friendly and enemy forces when making decisions. FFIRs provide the commanders with information that allows them to understand if they can undertake a given course of action. FFIRs are important information the commander needs to understand his own pattern or system. Together CCIRs form an initiation and condition relationship with the decision in the format of "if, and," and "then." For instance "if the enemy positions his reserves at position x (PIR); and the friendly main effort is preparing to move through the breach (FFIR), at least one battery is in position to fire (FFIR), we have priority of fires (FFIR), and the first echelon defense is suppressed by direct fires (PIR); then we can suppress the reserve with artillery fire to allow the main effort to maneuver." This simple illustration shows the relationship between PIR and FFIRs in decision-making. Note that in this case there are three FFIRs and one PIR that are conditions for this one decision. CCIRs are not only tied to decision-making, but are tied together to determine the complex inter-action of friendly, enemy, and terrain patterns. Therefore, to be most

beneficial current and developing DIS should in some way allow commanders to highlight these action cues to include the establishment of these type of conditional patterns.

It follows then that, in order to input this type of information highlight or filter, into a DIS the commander and his staff must be able to recognize the pattern in the first place. Recall that in *Decision Model* Klein discussed the decision maker's ability to recognize patterns. He stresses that novice decision makers tend to be less able to move from detection of changes within the pattern to choosing a course of action. In another study Klein reports on the tendency of these novice decision makers to focus their search for these action cues primarily on their own system, or other, more static, systems. The study, which compared new tank platoon leaders to experienced non-commissioned officers, reported that the novice platoon leaders focused as much as three times as much energy on understanding their own platoon's and the terrain's patterns.[5] The requirement to establish CCIRs as the inter-actions of several complex systems before the event's occurrence exacerbate the difficulty novices experience with detecting action cues. Novices may be unable to visualize these complex inter-actions. Further, they most probably could not develop a comprehensive set of CCIRs to provide input to a DIS as information filters.

This section began with a comparison of the MDMP and the RPD. This analysis established the primacy of RPD for decision-making during execution. Next, this section examined the information requirements associated with RPD and determined that the information required is a comprehensive set of information dealing with the complex inter-action of the belligerent forces and the terrain. Finally, this section briefly analyzed the abilities required by decision makers to establish these information requirements and determined that the experience of the decision maker is crucial to establishing appropriate CCIRs. The next section moves the analysis further into the combat environment, examining how commanders will deal with uncertainty while recognizing patterns, making, and implementing decisions.

Uncertainty in Combat

The final analysis examines the combat environment to find sources and effects of uncertainty that are relevant to the commander's decision-making during execution. First is an examination of how the environment will generate uncertainty in pattern recognition. Then the examination shifts to the impact of US Army doctrine on a commander's attempts to mitigate these uncertainties.

Due to the chaotic nature of combat, pattern recognition will be difficult, at best, for expert decision makers. As discussed in chapter four the collision of two complex, adaptive systems in a third complex system will generate an extreme amount of uncertainty. Remember that neither the friendly nor enemy force commander is in complete control of those units and soldiers under his command. Each soldier, in fact, is a complex, adaptive system capable of independent decisions and actions. Normally the process of co-evolution keeps the majority of these individuals subordinated, approximately, to the goals established by the higher complex, adaptive system. However, even within this consensus of goals between the individual and his unit there is significant room for deviation. Thus at any given time there will be a multitude of minor deviations from the central goals. These deviations manifest themselves as decisions by individuals and small units to take time to conduct unscheduled maintenance, rest, resupply, recreation, and a myriad of other divergent tasks. A decision by a platoon leader to send one of his vehicles on a "shower run" while another moves to the maintenance site for minor maintenance drastically changes the overall effectiveness and image of his platoon at that moment. When under fire, a number of individuals may simply remove themselves from the fight by going to ground. Others may pursue unimportant actions that, while certainly courageous, do little towards the overall unit goal. To an observer these random actions, in terms of the overall system, induce uncertainty by destructively interfering with his attempts to observe the reality of the system. All of these actions taken together add up to uncertainty in the mind of the commander. These

uncertainties related to specific, random actions make pattern recognition difficult whether the observer is concerned with his own or the enemy system.

The commander's efforts to control and redirect these types of random activities illustrate the application of the Second Law of Thermodynamics as applied to combat units. If left unchecked these random acts may combine to destroy the overall effectiveness of the unit. To be sure, some of these actions are both beneficial and desired. Commanders must balance control of the unit with their desire not to squash subordinate initiative. Thus, both friendly and enemy commanders observe their own forces to identify and stop destructive random patterns, while encouraging constructive random patterns.

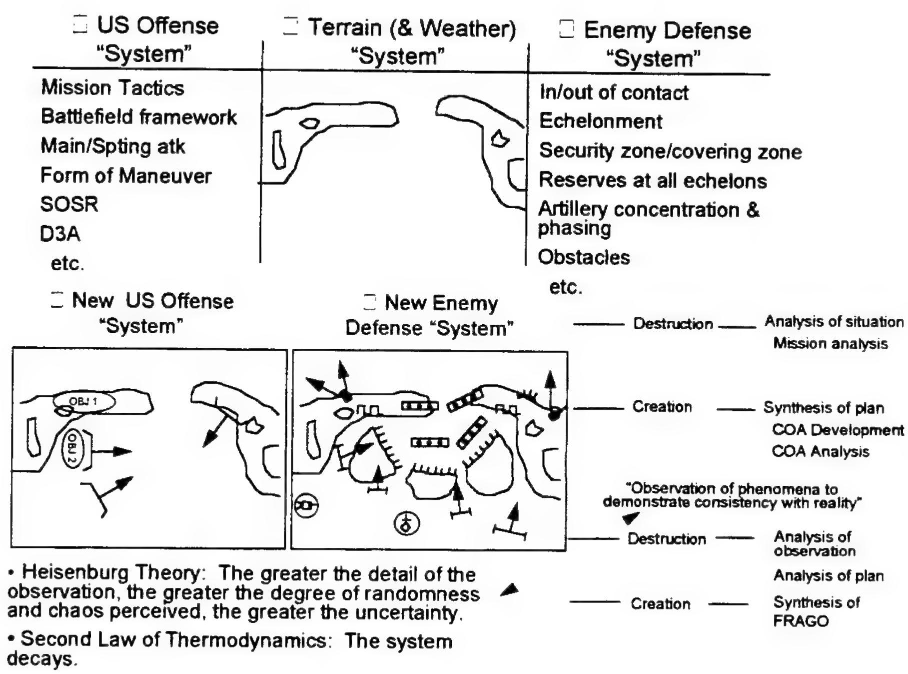

Figure 5. "Creation and Destruction" related by the process of "Observation and Orientation" to Heisenburg's Uncertainty Principle on the battlefield

Complicating the search for pattern recognition in this chaotic environment is the fact that both friendly and enemy commanders are attempting to gain this pattern recognition while preventing their counterpart from gaining it. Each commander has developed a course of action

designed to accomplish his ends, generally designed to defeat the other's plan. Each commander then attempts to verify the validity of his own plan by observing the other's. This is the process of creation and destruction as described by Boyd. Both commanders have analyzed the situation (destroyed the systems to their constituent parts) and then developed plans to achieve their ends (created a new system) based on their understanding of the original situation (see figure 5). The respective commanders then seek to verify the validity of his plan by conducting reconnaissance of the opposing commander's forces. Based on the results of the reconnaissance, each commander then revisits his analysis destroying the new system, including the results of his reconnaissance and his plan. As the commander considers necessary the plan is refined in an effort to have the plan match the reality. The reconnaissance plan acts as a driver for creation and destruction.

Along with seeking information about the opposing force, each commander also attempts to prevent the enemy from observing his unit. This results in any number of passive and active measures that further blur the observations of the enemy. These actions include, but are not limited to, direct actions against enemy reconnaissance forces, all types of deception measures, and deliberate changes to the force's disposition due to a belief that the enemy has gained the upper hand with information. Actions by subordinate unit commanders, small units, and individuals that are not directed by the higher commander but that are designed to enhance the survivability of the individual or small unit further impact on these observations. Finally, observations of the random actions described above add to the problem of verifying a plan's consistency with reality. This means that each piece of information collected has an associated uncertainty. Therefore, the commander cannot accept any information as certain in terms of predicting future events.

Thus, the commander must re-verify each observation to check its certainty and consistency with his perception of reality. The commander, or someone within his staff, must compare each observation with what he expected given the other observations that have already

been accepted to identify the enemy pattern. Therefore, the commander seeks to make new observations to corroborate the original observation. The need to verify observations based on other observation or preconceived ideas adds additional uncertainty. Contrasting this process of observation analysis with the Boyd model defines it as "observation-orientation." The commander, in his attempt to find the enemy pattern, continuously observes, orients, and observes again. Thus, the search for pattern recognition leads to an "observation-orientation" cycle.

Figure 4 depicts the input from DIS systems into the commander's decision-making cycle. The DIS serves as a system to transfer information to the commander and his staff and then to communicate the commander's decisions to the subordinate units. As discussed in the first section of this chapter, the DIS provides information as precise as that provided to it. Thus, the effect of DIS is to provide the commander with exactly the same information that is input by the sensor. If that sensor is a JSTARS then the commander receives whatever that sensor input into the DIS. If the sensor is a human then the commander receives exactly what that observer input into his DIS. Therefore, the only error in the report is the error induced by the sensor. However, the information provided by the DIS only shows what is happening now. The commander must still analyze the information to check the validity of his plan to reality. Additionally, the information provided does not predict future events, and so must be analyzed to determine what future events it could indicate. Again, the commander is driven to the "observation-orientation" and "creation and destruction" cycles. The difference between the DIS and the traditional information systems is that the commanders equipped with DIS are not limited to the number of sensors he can query. By having virtually real-time links to sensors the commander can quickly re-observe to verify initial observations. In effect this speeds up the "observation-orientation" cycle increasing the volume of discrete observations available to the commander.

However, at the battalion level the precise information provided by DIS and the nature of combat combine to increase the amount of uncertainty perceived by the commander. This is the effect of Heisenburg's Uncertainty Principle; precise, detailed observations of increasingly smaller

parts of the system induce more uncertainty. The random acts of individuals and small units blend with deliberate acts of deception and counter-observation to hide the indicators of the enemy's actual intentions. The probability that the enemy commander is both aware that he is being observed and actively refining his plan exacerbates these effects. The commander can never know if what is being reported is a random act, a deception, a reaction to his observation, or the actual planned location for a given enemy subunit. This also applies to friendly subordinate units. Constructive and destructive friendly patterns are difficult to differentiate when observed at the level of the individual vehicle. Therefore, the overall effect of DIS at the battalion level is to potentially increase the amount of uncertainty the commander perceives. Accordingly, the hypothesis put forth in chapter three of this study: <u>current and developing DIS enhances a battalion commander's decision-making during execution by providing high volumes of accurate and precise information that reduces his uncertainty</u> must be false.

Summarizing this section three yields general findings. First, the some of the actions of units in combat are randomly generated by individuals within that unit. Because of this complex behavior each observation of those units cannot be accepted as certainly predicting future events. Thus, each piece of information carries with it uncertainty. Next the need for pattern recognition to support decision-making drives commanders to an "observation-orientation" cycle. Units with DIS can increase the speed of this cycle, creating more observations of a precise nature. Finally, due to the precise nature of the observations DIS potentially increases the amount of uncertainty perceived by the battalion commander. The next chapter develops conclusions from the general findings developed in this chapter and sets forth recommendations resulting from these findings.

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[1]Department of the Army, United States Army Infantry School Special Text 7-20, *The Digitized Infantry Battalion* (Fort Benning, GA: Headquarters, United States Army Infantry School, 1996) 2-1.

[2]Department of the Army, Student Text 100-3, *Battle Book*, (Fort Leavenworth, KS: U.S. Army Command and General Staff College, Center for Army Tactics, 1996), 3-1 and 3-10 thru 3-13.

[3]ST 7-20, 3-2 and 3-3.

[4]ST 100-3, 3-2 and 3-24.

[5]Christopher P. Brezovic, Gary A. Klein, and Martin Thordsen, "Decision Making in Armored Platoon Command," ARI Research Note 90-51, Prepared by Klein Associates for the U.S. Army Research Institute for Behavioral and Social Sciences (Fairburn, OH: Klein Assosciates Inc., 1990), 15-19 and 30-31.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Does the chaotic environment of combat--the collision of several opposed complex, adaptive systems with a third complex system--prevent coherent analysis to the point that DIS can be of no assistance? Alternatively, can the combat environment be reduced to a puzzle that can be solved if one can only understand how the parts fit together? This study shows that combat cannot be reduced to a puzzle that can be solved with the right computer. DIS may not fulfill all the rhetoric associated with its development. However, battalion commanders, and commanders at other levels, stand to gain much from the application of DIS if they understand their own decision-making.

Although DIS is not the panacea that it appears to be to many in the US Army its application could enhance decision-making and information sharing if properly applied. Commanders must understand how information affects them and their subordinates. More, and more discrete information may obscure the critical action cues commanders need to make decisions. Certainty can never be achieved on the battlefield. Therefore the US Army should prepare its soldiers and leaders to deal with the effects of uncertainty. This study proposed to answer the question: Do current and developing DIS enhance battalion commanders' decision-making during execution? In the end, the study failed in this endeavor and, furthermore, leaves more questions than answers.

Major Findings

Much has been made of the capability of DIS to improve the availability of information for commanders to consider during decision-making. These improvements are generally expected in information accuracy, preciseness, and timeliness. The quantity of information is also expected to increase. In truth DIS functions much like its analog predecessors. The information provided by DIS is precise and as accurate as the sensor that collected it. The most relevant contribution that DIS make to decision-making is in quickly transmitting decisions and information to all those affected.

Whether the two selected DIS, ASAS and FBCB2, provide the right amount and type of information remains unanswered. The answer to this question is extremely dependent on the commander that will use the information. Perhaps this set of information is relatively stable. Future studies may focus on researching information requirements for decision-making in more detail. One thing is clear; the commander's need to recognize patterns should drive the development of these requirements.

There are two types of decision-making models, normative and naturalistic. Normative decision-making requires time consuming sequential analysis of multiple courses of action. These techniques attempt to isolate the best course of action. The MDMP is a normative decision model. Battalion commanders exist in a world of crisis decision-making. This environment virtually disallows normative decisions. The US Army recognized this environment and developed the single course of action technique for the MDMP for extraordinary situations. This technique is essentially a naturalistic decision model.

Naturalistic models focus on developing an acceptable solution to the problem at hand. As such, they allow an experienced decision maker to develop and implement a course of action quickly. Given the chaos of combat and compound nature of military problem situations, it is impossible to isolate the best solution to a problem. Therefore, battalion commanders use naturalistic decision-making processes, like RPD, to make decisions during combat operations.

Naturalistic decision-making drives the commander's requirements for specific action cues on the friendly and enemy situations and the terrain to initiate decisions. Action cues are discerned by observing alterations in the established enemy and friendly patterns. Novice decision makers have trouble in recognizing these patterns and action cues, especially those linked to enemy actions. A commander's CCIR is his set of action cues and, as such, should be developed before the event. Thus, a commander's experience is a critical factor in his ability to recognize patterns and predetermine CCIR.

However, random actions associated with the complex behaviors of combat units blur the patterns that provide action cues. As a result, the commander can never be sure of the validity of his observations. Moreover, an enemy may deliberately take actions to deceive the commander. The commander must always question if a given piece of information is an attempt by the enemy to cause him to develop erroneous conclusions about the enemy's intentions. Thus, each piece of battlefield information has an associated degree of uncertainty. This uncertainty further hampers the commander's ability to recognize patterns.

Commanders seek to mitigate uncertainty by effecting a cycle of observing and re-orienting, constantly refining their plans to match the situation. In this cycle of observation and orientation the commander attempts to refine his plan to match the reality he perceives on the battlefield. Simultaneously, the enemy commander is attempting the same thing. Each commander ties to prevent the other from observing his forces and discerning his intentions. As a result, the commander perceives more randomness in the enemy patterns, increasing his uncertainty. To mitigate this uncertainty the commander continues to observe, driving him farther into the observation-orientation cycle. Thus, the greater the commander's desire for perfect consistency between his plan and reality the more uncertainty he will perceive.

The capabilities of DIS increase the speed, and therefore, the volume of information made available to battalion commanders to drive these observation-orientation cycles. DIS generally provide very precise information, often to the level of individual systems in detail. At this discrete

level each action of the enemy, whether random or directed, stands out. Each of these actions requires the commander to question its relevance. Thus, the commander conducts ever increasing volume of analysis for each piece of information and its associated uncertainty. Therefore, the discrete nature of DIS observations increases the uncertainty perceived by the commander.

Conclusions

The developers of Force XXI seek to reduce the amount of uncertainty perceived by commanders by employing DIS to share information from a wide variety of collection platforms, reconnaissance assets, and other sensors. They expect to allow these commanders to make decisions faster because they will have more information available to them. However, as this study has shown more information does not reduce uncertainty. This is not information overload--the inability to comprehend available information--but the inability of commanders to predict with certainty future events based on the information. Commanders can only guess at the intentions of the enemy given his current dispositions. Even friendly information can induce uncertainty. A commander cannot know if the unit that appears to be out of position, is simply lost, or exercising initiative within his intent to accomplish a greater good. One can never know what is in the mind of another.

What reduces uncertainty is the ability to isolate critical changes in the patterns of actions. These critical changes allow the commander to visualize the effect of the enemy commander's decisions. This provides the commander with the ability to partially nullify the enemy's decisions by taking action to unbalance the enemy commander's plan. The ability to predetermine these critical actions, or action cues, is paramount in combat decision-making.

As Klein discusses, the most important factor in a commander's ability to recognize these pattern changes is his experience. The commander compares the current situation to his experience to develop these action cues. Combat information is the commander's link to the situation. He uses information to visualize the situation allowing him to identify action cues and

to develop analogues for course of action development. Battalion commanders in Force XXI are expected to have more information and to make decisions at a faster rate. Therefore, battalion commanders in Force XXI must have sufficient experience to provide them a depth of patterns and menu analogues to compare with the current situation.

This experience must be relevant to the environment in which the commander is expected to make decisions. That environment is chaotic and resistant to reductionist methods of analysis. People perceive their experiences in different fashions. Thus, the experience must be as consistent as possible to the decision-making environment. The greater the difference between the experience and the actual conditions of combat, the greater the chance for errors in pattern recognition and analogue development. Furthermore, details of experiences fade over time, possibly creating flaws in an individual's set of analogues. Therefore, the Army should reinforce an officer's experience as often as possible. The development of an officer's experience base and its reinforcement exercises his mind, preparing it for future decision-making. Training events that do not accurately replicate combat are ineffective for building this experience base.

An officer exposed primarily to training that does not allow uncertainty conceivably could develop a seriously flawed experience base. His unrealistic expectations of warfare include a sense of order that will not be reproduced in combat. This suggests that computer simulations and lane training are counterproductive for training officers to command and lead in combat.

Simulations and lane training posses an inherent order that does not replicate combat. In each case the terrain involved in the exercise is artificially limited and often known to the training audience. Each action of the enemy has meaning and is choreographed for precise effect. Oftentimes, the training unit is completely familiar with the plan of enemy actions and the terrain. In the case of lane training, the training unit knows what actions are expected of it. In fact, Army training doctrine virtually demands that the training audience understand which tasks are being trained.[1] The consequence of this type of training is the complete lack of uncertainty. Therefore, the majority of Army training does not prepare commanders and leaders to make decisions.

Moreover, officers must be conditioned to make decisions. The chaotic nature of combat demands that units be complex and adaptive. Decentralized decision-making is the best guard against uncertainty. By allowing subordinate commanders and leaders to make decisions within the scope of their unit mission and the commander's intent the commander can negate many effects of uncertainty.[2] Consequently the commander's experience must come from making and implementing decisions under these conditions.

How do Force XXI and the development of DIS relate to these conclusions? First, the expectation that DIS will allow commanders to decide faster is fatally flawed. Only experience will allow commanders to make solid, reasoned decisions in a timely fashion. Second, money spent on DIS is money not spent on training. This opportunity cost is rising exponentially. Reductions in Combat Training Center (CTC) rotations in 1998 are limiting the experiences of scores of future company, battalion, brigade and higher commanders. Platoon leaders that do not have multiple CTC rotations become company commanders with inadequate experience bases and so on. Reducing CTC rotations has a significant impact on future Army commanders and leaders at all levels. This is the true cost of Force XXI.

Recommendations

1. Recommend that the Commander, Combined Arms Center (CAC), direct the Army Research Institute (ARI) to conduct further research into the affect of DIS on decision-making at the battalion level. This research should address the evaluation of naturalistic versus normative decision-making and should involve a realistic combat training environment as possible. The research should specifically examine how DIS equipment impacts on the commander's perception of uncertainty in highly fluid situations. The focus of this research is significantly different from research currently ongoing as part of the current AWE. The AWE tends to focus on the capabilities of DIS to perform as intended while ignoring the larger, more important issue of its influence on decision-making.

2. Recommend that the Commander, CAC, direct that the Corps and Division Doctrine Directorate (CDD) consider a RPD type decision model for abbreviated decision-making for inclusion in revisions of FM 101-5, *Staff Organizations and Operations*. Further, the Commander, CAC, direct that combat, combat support, and combat service support branch schools adapt a RPD based decision model for battalion and lower level decision-making during execution.

This recommendation does not negate the requirement for MDMP and normative decision-making at any level. MDMP should be retained as the US Army's primary decision-making tool for pre-execution planning and preparation. Commanders at all levels should seek to use MDMP whenever the time and other circumstances allow. This allows the commander to exploit his staffs expertise and creativity. At division and higher level, commanders may always use the standard MDMP. Brigade and battalion commanders will have to balance the trade-offs between the best plan their staff can produce and the time they can allocate to subordinate preparation by selecting a plan that is acceptable.

This requires that commanders and leaders at all levels receive formal training on RPD based decision-making. Currently, US Army decision-making training may adversely affect a leader's natural decision-making by indoctrinating the leader to use normative processes when he would normally use a naturalistic process.[3] This leader training should involve requiring the leader to make decisions in a time constrained environment and then forcing them to deal with the consequences. Note that a significant part of this training is the leader's ability to recognize changes in patterns to initiate decisions. Thus, the leader cannot be cognizant of the decision oriented nature of this training. Leaders must be able to recognize situations where decisions are required without prompting.

3. Recommend that the Director of the Officer Personnel Management System, Task Force XXI, and the Director of the School for Command Preparation conduct a study of techniques for developing decision-making skills in future commanders. Officers identified as

potential commanders should be given specialized training and allowed a greater amount of tactical experiences to prepare them for command. A continuous pattern of operational assignments facilitates the officers' development of this experience base, the ability to develop analogues and recognize tactical patterns. These techniques should be incorporated into the School for Command Preparation.

4. Finally, the Commander, CAC, should direct a study on how the US Army can induce uncertainty into training environments. Allowing uncertainty in training is critical to developing experience in leaders and soldiers. Leaders at all levels must develop an experience base that is broad enough to allow them to recognize action cues and develop analogues for unique situations.

This type of training is significantly different from current training practices. Normally, units conducting training exercises strictly control opposing forces to generate training events. Likewise, the training units themselves are limited to ensure the desired event occur. The problem with this technique is that all concerned are aware of the need to make decisions. Moreover, there is little requirement to recognize patterns as the training scenarios and terrain vary little from year to year. The result is units that perform well during training exercises, but perform poorly in other environments. While the CTCs significantly increase the degree of uncertainty experienced by soldiers and leaders, they too are controlled more than they should be. CTC OPFORs and training units are limited to ensure that an engagement occurs in a given area, at a given time, within an established force ratio. This reduces uncertainty by forcing commanders into situations where they have no choice but to fight.

Further, by allowing subordinate commanders and leaders to make decisions within the commanders' intent the US Army facilitates the inculcation of leaders in mission tactics. Mission tactics, or initiative oriented fighting, is essential to mitigating the effects of uncertainty on the battlefield. These techniques empower subordinate leaders to use their initiative to make decisions. Subordinate leaders use initiative to adapt their units' actions to the reality of the

environment while keeping their actions focused on the goals of the higher commanders.[4] Thus, the uncertainty is dealt with by subordinate leaders before the commander becomes aware of it.

However, the commander cannot expect this type of initiative from leaders and soldiers who have never trained under conditions where they were expected or allowed to take initiative. The commander must allow his leaders to exercise initiative as often as possible. Otherwise, they will not be up to the task when needed. Ardant du Picq illustrates this point when discussing subordinate leader initiative in *Battle Studies*:

> Today there is a tendency, whose cause should be sought, on the part of superiors to infringe on the authority of inferiors. . . . The tendency is to oppress subordinates; to want to impose upon them, in all things, the views of the superior; . . . . He thus takes all initiative from subordinate officers, and reduces them to a state of inertia. . . .
>
> This firm hand which directs so many things is absent for a moment. . . . Immediately they are like a horse, always kept on a tight rein, whose rein is loosened or missing. They cannot in an instant recover that confidence in themselves, that has been painstakingly taken away from them without their wishing it.[5]

Thus, soldiers and leaders must be trained in an uncertain environment and be allowed to make as many decisions as possible. In this fashion the unit assumes its role as a complex, adaptive organization.[6] Complex, adaptive organizations not only cope with uncertainty, but thrive on it.

Closing

While this study fails to definitively isolate and measure the effects of digital information systems on decision-making at the battalion level during execution, it does provide insights into those effects. To understand those effects it is first necessary to understand how those commanders make those decisions. The study of human decision-making is fraught with inconsistencies and factors that cannot be defined because humans are complex, adaptive systems. It stands to reason then that the effects of DIS will be an unmeasurable quantity that may never be fully understood.

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[1]Department of the Army, Field Manual 25-101, *Battle Focused Training* (Washington, DC: Headquarters, Department of the Army, 1990) 4-5.

[2]Brian D. Prosser, "The Need for Training for Uncertainty," School of Advanced Military Studies Monograph (Fort Leavenworth, KS: U.S. Army Command and General Staff College, 1996), 46-47.

[3]John F. Schmitt, "How We Decide," *Marine Corps Gazette*, 79, no. 10 (October 1995), 19.

[4]FM 100-5, 6-5 and 6-6.

[5]Thomas R. Phillips, ed., *Roots of Strategy;* Book 2, *Battle Studies,* 8th edition, by Ardant Du Picq, trans. John N. Greely and Robert C. Cotton. (Harrisburg, PA: Stackpole, 1985) 236.

[6]Prosser, 47.

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